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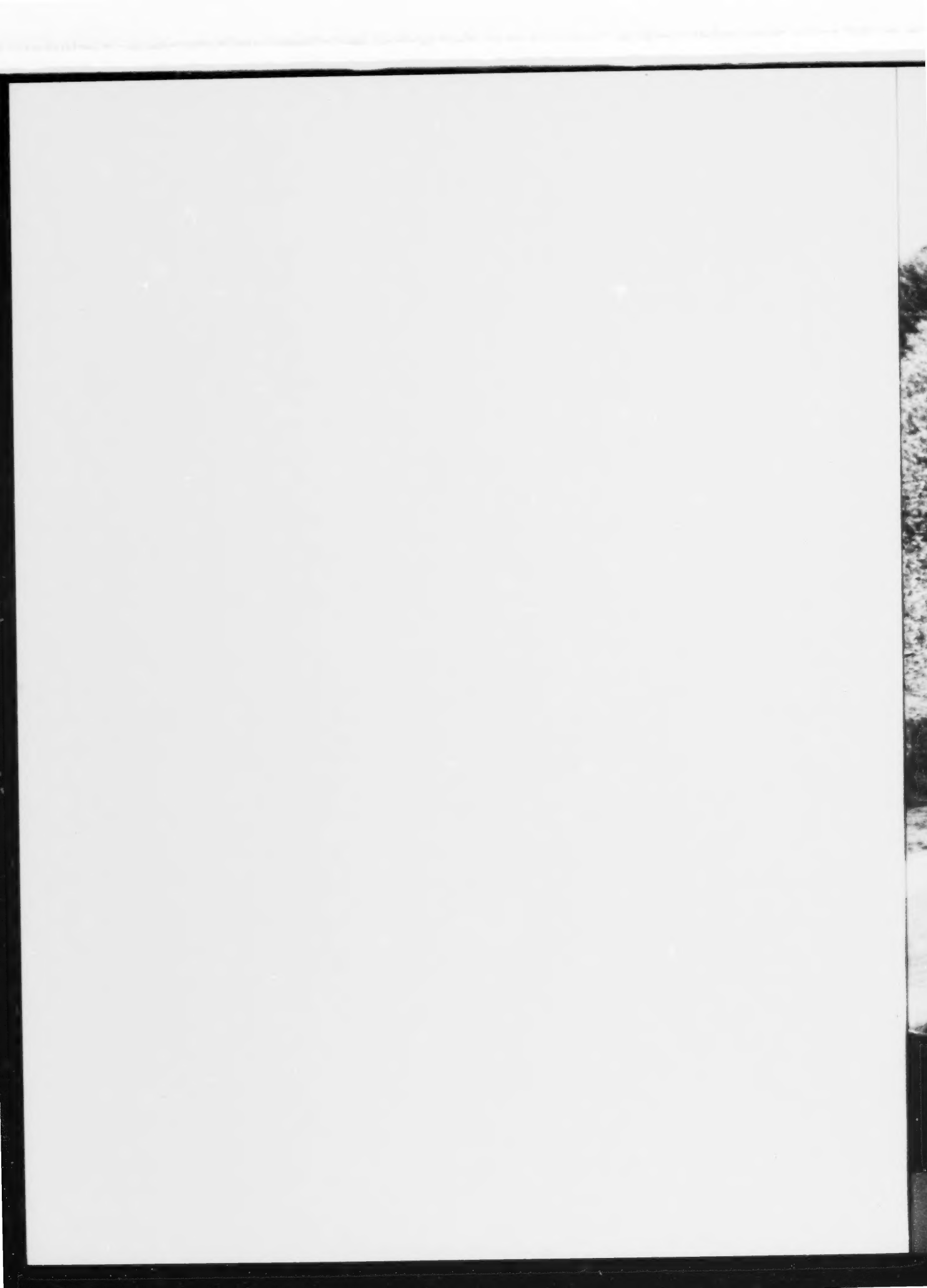
TURF IPM MANUAL

Publication 816

MINISTRY OF AGRICULTURE AND FOOD



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Introduction

This manual is intended for professional turf managers in Ontario. It has been designed to be used in turf IPM accreditation training and to serve as a basic turf IPM reference guide for turf managers. It has been designed to be part of a turf IPM study package that includes OMAF Publication 162, *Diseases and Insects of Turfgrass in Ontario*, and OMAF Publication 384, *Turfgrass Management Recommendations*.

The aim of this manual is to provide basic information on IPM, specific information on weed, insect and disease IPM for turf, as well as information on the safe handling and use of pesticides and sprayer calibration. Included are useful forms for recording pest monitoring information. Pesticide controls for specific pests are not contained in this manual, however, the most up-to-date information on registered pesticides is contained in Publication 384, *Turfgrass Management Recommendations*.

This is the first turf IPM manual for Ontario. We would appreciate receiving comments that will help us improve future editions of this manual.

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1. IPM (Integrated Pest Management) for Turf

Throughout this manual the general term "pest" refers to any insects, weeds, disease organisms, birds, mammals and other organisms that can be injurious, noxious or troublesome in turfgrass.

Integrated pest management (IPM) is a process that uses all necessary techniques to suppress pests effectively, economically and in an environmentally sound manner to sustain healthy landscapes. IPM employs a two-pronged approach: managing turfgrass to prevent problems and using "thresholds" to decide how and when to treat pests.

IPM is an approach that has been used for decades to manage insects and mites in agricultural crops. Over the last two decades, however, IPM methods have also been successfully applied to manage pests of all kinds, including weeds, plant diseases and animals. IPM programs are used in agriculture, forestry, landscapes and parks, home gardens and for structural pests.

In an IPM program, turf managers use regular inspections, called monitoring, to collect the information they need to make treatment decisions. A central idea in IPM is that a treatment is only used when pest numbers justify it, not as a routine measure. Applying pesticides according to a schedule based on calendar dates is rarely, if ever, done in IPM programs. This eliminates unnecessary pesticide use without sacrificing results. It is common to find pesticide use reduced by 60% - 80% when IPM programs are put in place. A pilot turf IPM project conducted by Laval University in 12 municipalities in Quebec was able to show a pesticide reduction of 61% over a three-year period. The key to success was eliminating unnecessary pesticide treatments and using spot treatments. Taking unnecessary pesticide use out of a pest management program also reduces the chance that pest populations will become resistant to pesticides.

Another important concept in IPM is that it is only necessary to keep pest numbers down to non-damaging levels. It is usually not necessary or even desirable to eliminate pests altogether. If treatment is needed, turf managers choose the combination of methods that suits the site and local conditions.

Integrated Pest Management

Integrated pest management is a process for suppressing pests that uses a combination of techniques, including but not limited to:

- planning and managing ecosystems to prevent organisms from becoming pests
- identifying potential pest problems
- monitoring and recording populations of pests and beneficial organisms, pest damage and environmental conditions
- using "thresholds" to make treatment decisions
- reducing pest populations to acceptable levels using strategies that may include a combination of biological, physical, cultural, mechanical, behavioural and chemical controls
- evaluating the effectiveness of treatments

— adapted from the Pest Management Regulatory Agency (PMRA)

In the short term, developing an IPM program may cost more for labour, IPM training and changes in equipment. To counteract this, IPM programs can be more cost effective because they can improve the quality of a landscape and reduce costs related to pesticide use (i.e., pesticide purchases, pesticide storage facilities and disposal). IPM provides a way to manage pests that have become resistant to pesticides and to deal with pests in places where pesticides cannot be used. It is important to realize that IPM programs change and improve as people gain experience, and as new products, tools and information become available.

The advantages of IPM programs are that they:

- provide long-term solutions to pest problems
- protect the environment and human health by reducing pesticide use
- reduce costs and liabilities associated with pesticide use
- prevent pesticide-resistant pests from developing

- enable turf managers to control pesticide-resistant pests
- may give good results where pesticides cannot be used

PLANNING AND MANAGING TURF

Planning and managing turf is perhaps the most important part of an integrated pest management program, and it is often overlooked. It takes careful planning to develop a site where turf can be grown with maximum health and minimum stress.

Planning

Soil Conditions

Two factors that must be considered in a golf course, sports field or other turf areas are root zone mixture and subsurface drainage. Turf that is grown on a compacted, poorly drained soil will be more prone to diseases, insects and weeds. A properly constructed and drained root zone will help minimize future turf problems. Fertility, pH and organic matter must also be taken into account.

Turf Selection

Another part of the planning process is selection of the appropriate turf species and cultivars for the intended turf use. Choosing cultivars resistant to pests and adapted to the climate and site, taking into account sun and shade conditions, winter temperatures, winds and patterns of use will result in fewer pest problems.

Turfgrass species characteristics are summarized in Table 1–1, *Turfgrass Species Characteristics and Recommended Uses*, on page 3. More information on turfgrass species can be found in OMAF Publication 384, *Turfgrass Management Recommendations*. Additional information on velvet bentgrass can be found in the section *Velvet Bentgrass*, on page 27.

Plant breeders are constantly releasing varieties with improved resistance to drought, insects and diseases. Be aware of new varieties and their attributes and stay up to date with data from turfgrass evaluation programs in your area. Results from the Guelph Turfgrass Institute variety trials can be found at www.uoguelph.ca/GTI. Results from the National Turfgrass Evaluation Program trials throughout the U.S. can be obtained from their Web site at www.ntep.org. Work closely with your local seed companies and keep informed of the latest releases.

Management

Irrigation

Careful planning of a turf area should be followed by good management practices. The importance of proper irrigation practices, including how much you water and how often, cannot be overemphasized. Watering too frequently can sometimes cause root death. Pore spaces that are usually filled with air will be filled with water when turf is watered too frequently, robbing turf roots of much-needed oxygen. Watering too shallowly will often cause the roots to be restricted to the upper 5 cm of soil. Either of these situations can cause turf stress, which may predispose turf to pest damage.

Fertilizing

Turf plant health is best maintained through a well-balanced fertilizer program. This can be determined by a soil test. Either too little or too much fertilizer can cause pest problems. Dollar spot will be rampant under a low nitrogen regime, whereas diseases such as *Pythium* and brown patch attack over-fertilized, lush turf. Refer to Appendix G, *Accredited Soil Testing Laboratories in Ontario*, on page 84, and the OMAF Web site at www.omaf.gov.on.ca for accredited labs in Ontario.

Mowing

Proper mowing height and frequency are also important turf management considerations. Mowing too low and not often enough can add to turf stress. A golf green that is mowed at 2–3 mm or a home lawn or sports field that is mowed at 3–5 cm will be more prone to stress and hence more susceptible to pest problems. Infrequent mowing can cause excessive removal of functioning green leaves (known as scalping of the turf). This affects carbohydrate reserves and root growth.

Thatch Control

Of equal importance is regular thatch control through verticutting and topdressing as well as aeration. Thatch harbours disease spores, and many insects also make their home in the thatch.

Aeration

Aeration is one of the cultural practices used on all categories of turf. It is used extensively on golf courses, sports fields and home lawns. Aeration:

- relieves soil compaction
- controls thatch
- enhances fertilizer penetration
- prepares turf surfaces for overseeding and renovation

TABLE 1–1.
Turfgrass Species Characteristics and Recommended Uses
(VH = very high, H = high, M = medium, L = low)
(E = excellent, VG = very good, G = good, F = fair, P = poor)

Species	Mowing Frequency	Establishment Rate	Nitrogen Req't kgN/100m²/month	Wear Tolerance	Drought Tolerance	Water Usage	Competitiveness	Thatch Formation	Shade Tolerance	Cold Tolerance	Recommended Uses	Seeding Rate (kg/100m²)
Kentucky bluegrass *Poa pratensis*	M	21 days	0.2–0.7	G	G	H	M	M–H	F–G	VG	Home lawns, sports fields, parks and sod farms	1.0–1.5
Supine bluegrass *Poa supina*	M	21 days	0.2–0.4	E	P	H	H	M–H	VG	VG	Sports fields and shaded greens. Should be seeded in a mixture with Kentucky bluegrass (10%–50% supine bluegrass, 50%–90% Kentucky bluegrass)	0.75–1.0
Perennial ryegrass *Lolium perenne*	H	4–6 days	0.2–0.5	E	VG	M	H	None	F–G	P	Home lawns, sports fields, tees on golf courses (not winter-hardy in all areas of Ontario)	2.5
Red fescue *Festuca rubra*	L	13–15 days	0.1–0.3	P	G	M	M	L–M	VG	G	Shady areas and low-maintenance areas on home lawns and golf course out-of-play areas	2.0
Chewings fescue *Festuca rubra* var *commutata*	L	Medium	0.1–0.3	F	G	L	H	M–H	VG	G	Shady areas and low-maintenance areas on home lawns and golf course out-of-play areas	2.0
Hard fescue *Festuca longifolia*	L	Slow to medium	Low but > sheep fescue	G	E	L	M	M	VG	G	Shady areas and low-maintenance areas on home lawns and golf course out-of-play areas	2.0–2.5
Sheep fescue *Festuca ovina*	L	Slow to medium	0	G	E	Best if not irrig.	M	M	VG	G	Shady areas and low-maintenance areas on home lawns and golf course out-of-play areas	2.0–2.5
Tall fescue *Festuca arundinacea*	H	Quite good	0.2–0.5	G	E	H	M	None	G	F	Sports fields, highways and boulevards (not winter-hardy in all areas of Ontario)	3.0–4.0
Creeping bentgrass *Agrostis palustris*	H	Medium	0.15–0.35	G	P	H	H	H	F	E	Golf course greens, tees, fairways and lawn bowling greens	0.3–0.5
Velvet bentgrass *Agrostis canina*	M	Medium	0.1–0.2	E	VG	M	H	VH	VG	E	Low-maintenance greens and fairways	0.3–0.5

Light and Air

Turf needs a minimum amount of sunlight to survive, and morning sun is preferred to afternoon sun. This ensures that the turf leaves dry off quickly in the morning, shortening the length of time the leaves are wet.

Air movement over turf is also essential to stimulate evapotranspiration, which is necessary for the uptake of certain nutrients and water.

"The best defence is a good offence" holds true for turf. Maintaining healthy, stress-free turf is fundamentally important and cannot be overlooked in an integrated pest management plan. A summary of good cultural practices can be found in the sidebar, *Proper Cultural Practices,* on page 4.

IDENTIFICATION

It is essential to identify pest problems correctly to plan effective pest management programs. First, identify whether or not there is a pest problem. In turf, plant damage can be caused by environmental conditions or cultural practices that stress or injure turf (such as drought, flooding, nutrient deficiency, fertilizer burn, herbicide injury, hydraulic fluid leak, localized dry spots, frost, salt, windburn, dog urine or scalping), as well as by pests.

Proper Cultural Practices

Irrigation

- Water infrequently and deeply.
- Time irrigation to minimize leaf wetness.
- Syringe (water very lightly) to reduce heat stress.
- Ensure adequate air movement and sun to dry off turf quickly.

Fertilizing

- Apply phosphorus (P) and potassium (K) based on a soil test.
- Adjust nitrogen (N) fertilization according to species and time of year.
- Use slow-release sources of nitrogen.
- Use an appropriate quanitity of nitrogen (N) to reduce dollar spot, red thread, brown patch and *Pythium*.

Mowing

- Mow as high as possible.
- Sharpen mower blades frequently.
- Use a lightweight mower if possible.
- Remove clippings from greens only.
- Never remove more than one-third of the leaf blade.

Aeration

- Aerate at least two times a year to reduce compaction, improve water and pesticide infiltration, improve soil profile, increase soil oxygen and break down thatch.

Once a pest has been identified, look up information on its biology, including life cycle, behaviour, preferred habitat, typical damage or symptoms and host plants. Knowing about the biology of a species helps to:

- concentrate monitoring efforts when and where pests are most likely to occur
- use treatments at the right time in the pest life cycle
- know if the pest has natural enemies that could be conserved or protected
- plan preventative measures and improve plant management practices

It is very important to identify beneficial insects and other natural enemies, as there may be enough natural enemies among the pests to control them in a few days without need for further action. Be careful not to mistake them for pests. More information on beneficials can be found in the section *Biological Controls*, on page 10.

To identify problems, collect insect specimens or samples of plant damage and compare them with reference materials. Suggestions on where to look and how to sample for common pests are discussed throughout this manual. Before sending samples for diagnostic services, contact the lab for recommendations on how to collect and handle samples.

To identify pests and beneficial species:

- compare specimens with an insect or weed collection
- refer to reference books, factsheets or resources on the Internet
- consult experts for help with difficult or unfamiliar species
- compare characteristics of damage or signs of disease with photographs

Be careful when using characteristics of turf damage to diagnose problems because similar-looking damage can have different causes. For example, dead patches of turf caused by a disease can look like damage caused by certain kinds of insects. If a disease had caused the symptoms, it would be useless to spray an insecticide. See *Diagnosing Turf Problems*, on page 5, for a step-by-step guide to identifying turf problems.

Make Your Own Collection

It is often easier to identify an insect or a weed by comparing it to a real specimen than to photographs. Make your own collection of insects (pests as well as beneficial species) and pressed weeds. These are useful for quick reference and for training employees. Also keep photographs of pests, damage and disease symptoms for future reference.

MONITORING AND RECORD KEEPING

Monitoring and record keeping consists of making regular inspections or counts and writing down the results. You will need monitoring records to make decisions about whether treatments are needed and when. Such records show where the pest problems are, and whether they are getting better or worse.

Monitoring is used to:

- detect problems while pest numbers are still low and before damage occurs
- assess the size and spread of a pest population and extent of damage
- find out if natural enemies of pests are present and in what numbers
- identify conditions that contribute to the pest problem

Diagnosing Turf Problems

1. Identify the turfgrass species affected.

- Symptoms may be affecting one species and not another in a mixed stand.
- Some diseases and insects are specific to one grass species.
- All species being affected may indicate a disease or insect with a broad host range or an abiotic (non-living) problem, such as drought.

2. Describe the symptoms.

- **Spots, rings or general thinning:** Some diseases form spots or rings (e.g., necrotic ring spot, dollar spot), while others cause general thinning (e.g., rust). Some insects cause general thinning.
- **Irregular patches:** Some may start as disease spots that coalesce or may be insect damage.
- **Regular or random pattern:** A regular pattern may be caused by equipment, e.g., failing to overlap spray pattern, fertilizer burn, hydraulic fluid leak).
- **Part of plant:** Note the part that is affected, e.g., leaves or roots.

3. Note the environment of the problem area.

- Sun or shade?
- Thickness of the thatch?
- Out in the open or near a building?
- Anything unusual about the soil?
- Anything unusual about the area?

4. What cultural practices have been performed?

- What is the mowing height and mowing frequency?
- Has the turf been fertilized recently (timing/amount/method of application)? Certain diseases favour high nitrogen while others favour low nitrogen.
- Has the turf been irrigated recently (timing/frequency/amount)? Some diseases are intensified by irrigation and others by drought.
- Has the turf been core-aerated (some insects like to inhabit aerification holes, and some diseases need the wounding of aeration or topdressing to infect the plant).

5. Note the weather conditions.

- What has the weather been like recently?
- What was the weather like right before the problem?
- Is the problem getting worse under certain weather conditions?

6. Examine the turf closely (this may require using a hand lens, knife or cup cutter).

- Look for lesions on turf blades.
- Look for the presence of mycelium on the turf.
- Look for the presence of insects, insect frass or silken tunnels in turf, soil or thatch.

7. You may need to take a sample.

- If you suspect a disease or insect, take a sample of turf with the soil intact (6–10 cm^2 with at least 4 cm of soil).
- If it is a ring or patch, sample the outside edge.
- If it is general thinning, sample an intermediate area.
- Wrap the sample in newspaper or paper towel.
- Do not treat turf with pesticide before sending a sample.
- Clearly label the sample and insert field observations.
- Send the sample by courier to the Pest Diagnostic Clinic.
- If you suspect a chemical problem, take separate samples from the affected and non-affected areas.
- Sample soil only.
- Submit sample to a pesticide residue lab.
- Tell the lab what pesticide(s) you suspect.

- determine what effect treatments or natural enemies have had on the pest population

A monitoring program consists of:

- a series of inspections or counts, done at regular intervals
- written records of the observations and counts

Always write down counts and notes at the time they are made so that the information is accurate. Use a well-designed record sheet to enter information; this saves time and makes sure important information is not left out (for examples, see Appendix A, *Turf Scouting Record*, on page 79, and Appendix B, *Golf Course Pest Scouting Form*, on page 81). For efficiency, some companies have staff enter records into a portable computer at the site. Such records can be quickly downloaded to the company's database. Some companies are developing electronic spreadsheet versions of the monitoring forms, which are efficient ways of handling large amounts of information.

When and Where

The time and place to start monitoring depends on the site, the plants and the pest involved. By learning about the life cycle of various pests, you will know what plants they are most likely to attack and when. For example, an ideal time of year to look for European chafer grubs is early August, after a heavy flight of adult beetles occurs.

How Often

Frequency of monitoring varies with the pest and conditions. For example, weeds in turf may be counted once or twice a year, whereas monitoring for insects is often done weekly during the time of year they are expected to appear. Monitoring for fungal diseases in turf might be necessary every day or two in damp weather. Frequency of monitoring also depends on the priority given to the turf. Golf greens and tees, for example, are usually monitored daily, fairways and sports fields weekly, and passive park turf and roughs once a season.

What to Record

Examples of information to record include:

- species of turf and their locations
- weather conditions, such as temperature and humidity
- counts of pests and beneficial species
- counts or notes of damage or symptoms
- notes on site conditions that may be relevant
- growth stage of other plants in the area (called phenology, see the section *Plant Phenology*, below)

Not all of this information is useful in every case. With experience, it will be possible to narrow down what information is most useful and suited to the situation. Understanding plant phenology and identifying the key pests that are the most troublesome to your kind of turf can help you narrow down when, where and what to monitor.

Plant Phenology

Phenology is the relation between climate and biological events — in this case, plant development, such as blooming, leafing out, etc. Plant growth depends on temperature, so the date a particular plant blooms depends on how the weather has been. Although the calendar dates may differ from year to year, plants generally develop in the same relationship to each other. For example, wild cherries bloom before lilacs, which bloom before horse chestnuts; particular cultivars bloom earlier or later than others.

Since insect development also depends on temperature, it can be more accurate to relate the appearance of particular insects to plant phenology than to a calendar date. For example, peak adult flights of black turfgrass ataenius occur at the same time the horse chestnuts in the area begin to flower. Use plant phenology as a guide to help target monitoring to the most likely time to expect the pest. Refer to the "Summary of Insect Sampling Techniques," in OMAF Publication 162, *Diseases and Insects of Turfgrass in Ontario*, for examples of plant phenology species used to remind when to monitor turfgrass pests.

Key Pests

Know which pests are of the most concern to your kind of turf so you can focus on monitoring the most important problems.

Monitoring Methods

The many techniques for monitoring pest numbers and activity can be divided into two main approaches: visual inspections and counting methods. The most common counting techniques are described below. For details on other methods, see the sections on *Monitoring* in Chapters 4 through 6.

Visual Inspections

A visual inspection is a good, close look, often taken through a magnifying lens. Best done at regular intervals, while keeping notes, visual inspection is the most subjective monitoring method — this means that what is seen and recorded depends on the knowledge and skills of the person doing the looking. Visual inspections are most useful to ascertain whether pests or beneficial species are present. They are also useful for checking plant health and soil and moisture conditions and for quickly finding problem sites, such as unusually weedy patches in turf or a turf disease.

Tools for Visual Inspections

- 10–15X magnifying lens or headband magnifier or dissecting microscope
- vials or plastic bags (to hold samples to be examined later under a microscope)
- notepad or pre-printed forms, pencils
- pocket knife
- small trowel or soil probe for checking soil conditions

Counting Methods

Counting methods for monitoring pest populations are well developed for only a few problems, such as weeds in turf. The advantage of using counts in monitoring wherever possible is that they give numerical (quantitative) measurements. Unlike visual inspections, such measurements give numbers that can be compared from year to year as long as the same method is used each time.

For example, you could count the number of:

- insects in an area of turf
- weeds in a measured area of turf or along a length of roadside or sidewalk
- disease spots per area of turf
- insects caught in pheromone traps

Insect Traps

Insect traps are used to:

- find out when the first adult insects are present
- estimate the time when the population peaks
- estimate the size and extent of a pest population

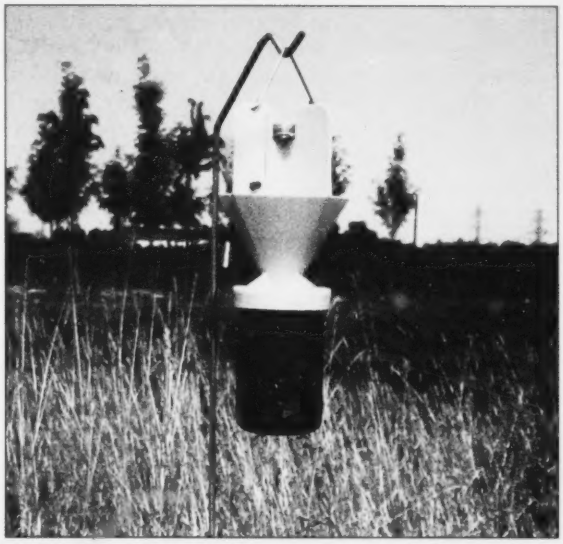

FIGURE 1–1. Pheromone trap used to monitor Japanese beetle populations.

Pheromone Traps Most pheromone traps contain synthetic sex pheromones that mimic the odour given off by females to attract males for mating (see the sidebar *Semiochemicals: How Insects Communicate*, on page 8). Pheromones are so specific that a different pheromone (or blend of pheromones) is needed for each species. This makes them an excellent monitoring method because they catch only the target insects. The traps are used to find out when the main flights of adult moths or beetles occur so that sprays or biological controls can be used at the right time to have the greatest effect. The pheromone is usually contained in a rubber or plastic lure that is hung inside a cardboard trap, such as a wing trap. The inside of the trap may be coated with sticky glue, which catches the insects that enter. To inspect the trap, open it up and count the captured insects (see Figure 1–1, above).

Use pheromone traps to monitor Japanese beetle populations. Check traps weekly, and either count or weigh and record the number or weight of insects caught.

Black Light Traps Light traps help determine the relative abundance of insects in a defined region. Black light traps, which emit ultraviolet light, are commonly used to sample nocturnal (active at night) species. Black light traps attract adult black cutworm moths very effectively. Use the traps to determine when the adults first begin to fly and when those flights peak in number. Portable black light traps allow you to know which insects are present, enabling you to be certain you treat for the right pest and identify unusually high pest activity from

Semiochemicals: How Insects Communicate

Semiochemicals, meaning, literally, "message chemicals," are chemical compounds that insects use as signals. These include compounds given off by plants that attract or repel insects as well as message chemicals produced by the insects. Semiochemicals that insects use to communicate with members of their own species are called pheromones. For example:

- sex pheromones are emitted by females to attract males
- aggregation pheromones are emitted to attract others
- alarm pheromones are emitted to warn others

Sex pheromones are most commonly used in monitoring for a wide range of moth and beetle species. An increasing number of other semiochemicals are becoming available to manage other pests by affecting their behaviour. Semiochemicals are being used to disrupt mating in insects, to trap them in large numbers, to attract them to toxic baits or to lure them to places where other treatments can be used.

site to site. The simplest light trap consists of a UV light (often called a black light) and a collecting pan with alcohol covering the bottom. The pan is placed below the light, and insects flying toward the light eventually drop into the alcohol. Commercial light traps of various designs are also available. Most of these consist of a light source, a series of baffles, a funnel and a killing jar. The jar usually contains alcohol as the killing agent.

Reliability of Counting Methods

The point of counting pests (or pest damage, beneficial species, etc.) is to get an estimate of the pest presence. Two main factors determine how reliable counts are in showing the true state of the pest population — sample size and sample randomness.

Sample Size To get a meaningful figure, count between 10 and 50 samples (such as insects on leaves or weeds in squares of turf) and average the results. The more samples you take, the more likely it is that the average will be a true picture of the pest presence — but there is a practical limit, because time spent on monitoring is a labour cost. A way to determine how many samples are enough is described in the sidebar *How Many Samples Are Enough?*

Sample Randomness Make sure that samples are picked at random. This means picking them by chance, without looking at them first and deciding which to take. If you intentionally choose particular leaves or other units to count, the results likely won't give a good estimate of the pest situation. For example, one way to count weeds in a lawn is to lay a 1-metre-square frame on the grass and count the number of weeds inside. If you chose the only weedy spot in the lawn, your records would seem to show the whole lawn was full of weeds. If you chose the only weed-free area on a lawn, the opposite would appear to be true. Only by dropping the frame randomly on the lawn a number of times and calculating the average weed count, would the results be likely to tell you the average weed infestation in the lawn.

One way to take a sample randomly, in the case of the turf example, above, would be to close your eyes, walk a few steps, drop the frame and count the weeds wherever it landed. Another way to ensure randomness is to decide a pattern of sampling ahead of time and stick to it. For example, you could lay out a grid pattern on turf and count the weeds only at the intersection points.

How Many Samples Are Enough?

Sampling involves statistical theory — and can get very complex. Luckily for most landscape pest monitoring, a reasonably good estimate will do. Here is one way to estimate how many samples to take:

First:

- Take 10 samples and count the pests (e.g., number of weeds/metre^2).
- Add up the total number of pests in the samples and divide by 10 to get the average.

Second:

- Take 40 samples, count the pests, add up the total and divide by 40 to get the average.
- Compare the average of 10 samples with the average from 40 samples.

If the averages are the same or close (within 10%–20% of each other), it shows that the higher number of samples probably wasn't necessary; taking 10 samples is likely to be enough. If there is a larger difference between the two averages, however, take more samples. Try an average of 15 or 20 samples to see if the averages are closer to the 40-sample average.

(Adapted from: Daar, S., H. Olkowski, and W. Olkowski. 1992. *IPM Training Manual for Wholesale Nursery Growers.* Bio-Integral Resource Center, CA.)

Ensuring samples are random doesn't mean that you have to sample over a wide area or in places where the pests are not likely to be. It is most efficient to concentrate on sites where the pests are most likely to appear (hot spots). For example, we know that European chafer beetles mate in trees and the females lay their eggs at the base of trees. These are good areas to sample first for grubs.

Radiometers It is not difficult to recognize stressed turf. Yellow, wilted, worn or bare patches are easily identified and associated with compaction, disease, nutrient deficiencies or drought. The challenge is to detect stressed turf before it is visible to the human eye and to find rapid, reliable and inexpensive tools that can help identify stressed turf. One new experimental technique analyzes light reflected from turf. All plants reflect, absorb or transmit certain wavelengths of light energy. Turfgrass appears green because it reflects green wavelengths. Because absorption, transmission and reflection change with plant stress, cameras capable of measuring reflectance from the grass could be used as tools to monitor turfgrass health.

In research under way at Auburn University in Georgia, radiometers were used in research plots that have had a compaction stress applied. The results indicated that reflectance of bermudagrass in the visible range increased as compaction increased, highlighting a direct relationship between the two. These instruments were also able to document subtle differences in visible light reflectance that may not be obvious to the eye. The challenge will now be to determine the exact source of the stress revealed by radiometers. Studies with other variables such as water application, nitrogen fertility, turf cultivar and weed species have shown that these also affect spectral images. Although research is still needed to help separate the causes of turf stress, perhaps the time is not far off when routinely arranged aerial flyovers of golf courses or handheld radiometers for lawn care will be able to locate stress situations ahead of damage.

THRESHOLDS

"Thresholds" are the number of pests that turf can tolerate before there is unacceptable damage. When pest levels exceed the threshold, control action should be taken. It is important to remember that most thresholds are simply guidelines. Factors involved in determining thresholds are:

- the overall health and vigour of the turf
- what part of the turf is affected
- what pest is involved and the risk of permanent injury or death to the turf
- the amount of visible damage the pest causes
- the location of the problem area in the landscape
- the attitudes and perceptions of people who use the turf
- the cost and effectiveness of treatments

Thresholds have been established for many common turf insect pests. Weed and disease thresholds are somewhat more subjective and should be established in consultation with the golf course membership, turf user group, clients, etc.

What Is a Pest?

In IPM programs, the term "pest" is usually used as a characteristic of a population of organisms. This means that individuals of a species are not usually "pests." They only become pests when there are too many of them, in the wrong place.

To decide whether or not treatment is required, use the information from your regular monitoring program. Often there is no need to take any action, either because the expected pest is not found or because it remains at numbers well below the threshold. When pest numbers rise higher and are reaching the threshold, treatment is required. Sometimes, however, it is necessary to monitor more often or more widely to be able to make a decision.

CONTROLS

Ideally, controls are only needed where preventative or cultural measures have not solved a pest problem or when pest levels exceed the action threshold. Often, however, an IPM program starts with an existing pest problem that must be dealt with before the turf manager can plan a prevention program. Controls used in turf fall under five general types:

- cultural
- physical
- mechanical
- biological
- chemical

Other categories could be added to the list, especially as research develops new controls. In agriculture and forestry, insect semiochemicals have been developed to affect insect behaviour on a large scale, so these are often called behavioural controls. Some methods fit into two categories (e.g., sanitation can be considered either a cultural or a physical control). Therefore, categories aside, the important thing to know is that turf managers have a wide variety of control "tools." These can be used separately, or in combinations, to give the required level of control. Using a combination of controls is usually more effective than relying on any one control. This is because each measure contributes to reducing the pest population; even if the effect of each measure is small, altogether they add up to effective control.

In choosing treatments, select methods that are:

- least hazardous to human health
- least toxic to non-target organisms
- least damaging to the environment
- most likely to produce long-term results
- most cost effective over time

Cultural Controls

Cultural controls or practices are key factors in producing healthy turf. For an overview on cultural controls, see the section *Management*, on page 2. Another example of a cultural practice is sanitation.

Sanitation

Remove potential breeding sites for pests and destroy sources of infection. For example:

- Pull weeds that act as hosts for insects and diseases.
- Remove trash and plant debris and grass clippings that harbour rodents, overwintering insects, insect eggs or disease organisms.
- Pull or cut weeds before they set seed and spread to other areas.

Physical Controls

Physical controls include manual techniques, such as hoeing or pulling weeds. Some controls can be considered either physical or mechanical, therefore they are usually grouped together in the sections on *Controls* in Chapters 4 through 6. Physical controls also include passive techniques, such as barriers and traps.

Barriers

Barriers stop pests from reaching their food supply. Examples include:

- weed barriers, such as mulch mats, landscape fabric or mulches of leaves or bark that smother germinating weeds
- animal barriers, such as deer fences, bird mesh or copper strips to keep out slugs

Mechanical Controls

Mechanical controls are machines or devices used to control pests, such as vacuum equipment for insects and cultivators, mowers and line trimmers used to control weeds. Other examples include:

- heat applicators, such as propane flamers, hot-water or steam applicators and infrared radiation equipment, used to kill weeds growing in cracks in hard surfaces, under fence lines and along roadsides
- animal repellers, such as devices that squirt water when activated by a motion sensor to frighten deer, racoons and other animals

Biological Controls

Biological controls use natural enemies of pests to control pest populations. Many biological controls are beneficial insects and mites but they can also be larger animals, such as birds and snakes, and microorganisms, such as fungi and bacteria.

Employ biological control by:

- protecting and attracting the many natural enemies that are native to Ontario
- using natural enemies from commercial suppliers such as parasitic nematodes for white grub control

Protecting Natural Enemies

The most important way to protect beneficial species is to avoid using pesticides as much as possible, especially those that affect a wide range of species or that are very long lasting. If pesticides are needed as part of a pest management program:

- choose the most selective products with the lowest toxicity and/or shortest residual effect on non-target organisms
- limit applications to only those areas that are infested (spot treating)

Chemical Controls

A large variety of chemicals (and some micro-organisms) are registered as pesticides in Canada for use on turf. Pesticides are defined as any substances used to kill, control, repel or manage insects, rodents, fungi, weeds and other living things considered to be pests. Pesticides vary greatly in their toxicity and the way they work. In IPM programs, pesticides should only be used after careful assessment shows that they are the best control for the situation. Applying pesticides only when monitoring shows that the threshold has been reached is economical and eliminates unnecessary pesticide use. Only apply pesticides with a properly calibrated sprayer.

Note: ONLY pesticides with a *Federal Pest Control Products (PCP) Act* registration number on the label may be used for pest control. Pesticide products may only be used for pests and in locations specifically listed on the label. Always read the label before using any pesticide product. The pesticide label is a legal document and failure to follow the label is breaking the law.

When you decide to use pesticides, choose the most suitable formulations and methods of application. Take all possible precautions to prevent the exposure of people and non-target organisms to the pesticide. To limit the negative effects of pesticides:

- choose pesticides that present the least short- and long-term health risk to humans
- choose pesticides that have the lowest environmental impact, usually because of short residual effects or because they specifically affect target pests
- choose application methods that limit the amount of pesticide used and limit pesticide drift (shrouded sprayers)
- limit treatments to only the plants or sites where pests are a problem (spot treatment)
- notify anyone who might enter a treated area so that they can avoid exposure by following the posting regulations

The characteristics of specific preferred pesticides are described in the section *Pesticides*, on page 34.

Other Pesticides

Products containing toxic and/or persistent chemicals, such as organophosphate and carbamate insecticides, are registered for some turf pests. These may be necessary in some cases, particularly as a short-term measure. Generally, however, these products should not be used when preferred pesticides or non-toxic methods are available. This is because there is greater risk of harming non-target organisms, and the hazards associated with improper storage and disposal are higher with these products than with preferred pesticides.

It is worth noting that federal review processes for organophosphate pesticides in the U.S. and Canada are under way. This may result in restrictions on some commonly used products within a few years.

Pesticides currently registered for use on turf in Ontario can be found in OMAF Publication 384, *Turfgrass Management Recommendations*.

EVALUATION

Evaluation is an essential part of every IPM program because it helps:

- determine what worked and what didn't
- identify ways to improve the program
- assess the costs and benefits of the program
- identify changes to site design and management to prevent future problems

To evaluate an IPM program, you will need accurate records of treatments and results from:

- monitoring records of pest numbers and locations before treatment
- treatment specifics, including date, time, product names and rates used
- monitoring records of pest levels after treatment
- feedback from clients or site users

Keep accurate records of labour and other costs so you can set a fair price for IPM services.

WHY USE IPM AND REDUCE PESTICIDE USE?

Much of the interest in promoting IPM is a result of:

- a goal to reduce the exposure of humans, pets and other non-target organisms to pesticides
- the development of pest populations that are resistant to pesticides
- the development of new pest problems when the natural enemies that were keeping them in check are destroyed by pesticides

Compared to other types of controls used in IPM programs, pesticide use:

- provides short-term control, but rarely a long-lasting solution to pest problems
- requires effort and expense for turf managers to provide adequate training, safety equipment and pesticide storage facilities
- requires careful planning and use of application techniques that protect people and the environment
- causes inconvenience (and concern) to site users who want to avoid treated areas

Pesticide-Resistant Pests

Pesticide-resistant pest populations are a major problem in agriculture and, to a lesser extent, in other sectors. Resistance appears when a pest population is repeatedly treated with the same pesticide. A few individuals in the population may survive a spray because they have genetic characteristics that make them resistant. When they breed, they produce offspring that are more likely to survive the next time the pesticide is used. As each spray kills the susceptible individuals, the resistant individuals continue to reproduce. Eventually, the whole population is made up of individuals with resistance to the pesticide. Pesticide resistance has been found in insects, mites, weeds and rodent populations.

The best way to prevent the development of pesticide resistance is to use non-pesticide methods whenever possible. This also ensures that when pesticides must be used, they will still be effective.

Pesticide Risks to Non-Target Organisms

Many common pesticides are broad-spectrum poisons. If used improperly, they can harm people and other non-target organisms, such as pets, plants, beneficial insects, wildlife, birds and fish. Generally, broadcast applications of residual pesticides pose the most risk.

CONCLUSION

The basis of a turf IPM program is prevention of pest problems, careful planning and management of the turf. If controls become necessary, the IPM approach gives the turf manager a step-by-step process for managing pest problems. The emphasis on monitoring pest populations before making treatment decisions differs from the practice of applying pesticides based on a calendar schedule. The challenge to the turf manager is to approach pest control differently. This approach is a more environmentally sound approach than a short-term, "chemical bullet." This is also true for lawn care where clients are used to scheduled pesticide applications.

An increasing number of clients are demanding an IPM approach because they are concerned about pesticide use and environmental safety.

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2. Steps for Developing an IPM Program

This chapter describes the practical steps for developing an IPM program. Most of this information should be useful for anyone involved in managing turf pests, whether they are new to the IPM approach or are looking for ways to improve an existing IPM program. Suggestions for managers of lawn care companies and parks or golf course superintendents are also included in the section *Manage for Success*, on page 26.

DEVELOPING A TURFGRASS IPM PROGRAM

The following seven general steps include tips from turfgrass professionals who have worked out ways to apply IPM methods in their practices. Not all of these steps will apply in every case, so use what makes the most sense in your situation.

1. Set Realistic Objectives

Trying to make a lot of changes at once is hard to do successfully — and can be discouraging if things don't go well. Start with manageable goals and well defined objectives. Write them down. For example, you could start by choosing to work on:

- one site, a small part of a large site or a limited number of smaller sites, or
- site(s) with the fewest pest problems, or
- key pests

Where to start depends on the types of plantings and pest problems being managed, as well as what type of agency or business is involved. For lawn care services with residential clients, an excellent way to get started is to work with a few customers who are interested in IPM. To find these people, ask for volunteers (e.g., by personally talking to clients or by putting a note in with monthly account statements or in a company newsletter). A good time to involve clients is early in the season when they are beginning to make plans for their landscapes. You can learn a lot by working closely with these clients, keeping them informed and asking for their feedback as you go. As you gain experience, you will develop the skills and confidence to apply IPM to more accounts.

2. Categorize the Sites

To set priorities for an IPM program, divide turf sites (or parts of large sites) into categories according to the level of maintenance they require. This makes it easier to see where to concentrate efforts and helps with decisions about managing pests. Thresholds, for example, will vary with the purpose and visibility of the site. The amount of money and time worth spending on treatments also varies with the type of site. High-profile sites usually warrant using the most resources for monitoring and pest management. In contrast, there may be no need to monitor or manage pests in some low-profile sites.

The following classification system is used throughout this manual.

- **Class A:** High level of service — residential lawns, golf and lawn bowling greens, golf course tees, irrigated sports fields
- **Class B:** Moderate level of service — sports fields, commercial lawns, golf course fairways
- **Class C:** Low level of service — passive park areas (including picnic areas), naturalized areas, golf course roughs

3. Assemble Background Site Information

The more background information you have about a turf area, the better your IPM plan will be. Background information on a site includes historical information, expected pest problems, treatments available, resources available and regulatory requirements that may apply.

a) Collect historical information, including:

- notes, observations and other written records of weather, site conditions, pest problems, plantings, fertilizing schedules, etc.

- spray and other treatment records from previous years
- account records showing what work was done
- staff interviews

Ideally, this information is available and only needs to be organized; in reality, however, records may be scarce. For newly established sites, records will not exist; in this case, past experience with similar landscapes in the region could be used as a guide. Extension publications on pests of the region are also useful references for what to expect. For new clients, arranging a meeting to discuss problem areas in the landscape may provide helpful background information.

b) Find out about pests likely to be problems and collect information on:
- life cycles and biology
- range of host plants that may be affected
- conditions that favour the pests
- conditions that prevent pest development
- natural enemies of the pests

See Appendix F, *Resources*, on page 83, for a list of suggested resources.

c) Research the range of treatments available, including:
- which pests they are effective against, and, in the case of pesticides, which pests and locations of use they are registered for
- mode of action of chemical pesticides and how well they are expected to work
- factors that would limit use to specific times or places, such as temperature, relative humidity, moisture conditions, life stage of the pest affected, toxicity, time of day the pest feeds
- cost and availability from suppliers

d) Make an inventory of the resources available for the IPM program, including:
- budget for labour, supplies, travel, new tools, reference manuals, capital items and training
- people, in terms of time available and their skills, interests and qualifications
- supplies, tools and equipment on hand

e) Know the regulatory requirements and guidelines that apply, including:
- provincial legislation regarding pesticide use. These can be found in the *Pesticides Act*, Reg. 914 (available on the Internet at www.e-laws.gov.on.ca).
- municipal bylaws that may ban or further restrict pesticide use, specify pesticides that may or may not be used, or require posting or notification of pesticide applications. Water-use restrictions may also be in place, which will affect management plans for turf.
- local school board, hospital board or other agency policies on pesticide use or pest management methods that may be used.

4. Conduct a Site Assessment

A site assessment is a systematic inspection to collect current, site-specific information. Make a scale map of each site and record this information on it. Producing site maps involves some extra work at the beginning, but they are tools that will be useful for many years. The site map can be as simple as a hand-drawn sketch kept in a binder or as sophisticated as a computerized map with links to electronic files about the site. Software packages for mapping and designing landscapes are available from software dealers.

The types of information to record in making a site assessment include:

a) Physical characteristics
- Record soil conditions, such as type (sandy, loamy, clay), depth of topsoil and drainage; take soil tests to determine pH, fertility, organic matter content, cation exchange capacity (a measure of nutrient availability).
- Describe micro-climate conditions. Within the overall climate of a region, there are micro-climates of temperature, exposure to sun, wind and shade, frost patterns and air circulation that can make a large difference to the health of plants.

b) Plant inventory
- Identify the species of turfgrass and also the cultivars, if possible, as many vary widely in growth habit, management and susceptibility to pests, and record their locations. Information on cultivars of turfgrass species may be available from seeding records on golf courses or sports fields. On home lawns, this information is not usually available.
- Inspect each site and note whether the turf is healthy, has pest problems, shows signs of nutrient deficiency, has growth abnormalities, thinning, etc. Since the basis of an IPM program is

prevention by growing healthy plants, this assessment of plant health is essential information.

c) Use patterns:

- Note who uses the site, how often and for what purpose. This will be useful for developing acceptable injury levels and selecting the most suitable treatments.

A large municipal park usually contains several areas with differing purposes and users — from picnic areas to playing fields to display gardens. Even within small, residential landscapes, there may also be differences in use and purpose. For example, appearance may be most important in the front yard, whereas safety for children at play might be most important in the backyard. On a golf course, the appearance of the greens and tees is more important than that of the fairways. In an IPM program, these differences would translate into differences in treatment thresholds and treatments.

d) Environmental concerns:
No turf exists in isolation from the rest of the environment. How turf is managed can affect much more than the immediate users. In the site assessment, look for conditions that should be taken into consideration, such as:

- potential for runoff that might erode soil or carry pesticides and fertilizers into water bodies, ditches or storm drains
- use by wildlife, such as birds, mammals, butterflies and others
- impact on neighbouring properties, as a result of changes to the landscape design or the type of treatments used

This information is also useful in setting treatment thresholds and choosing treatments.

5. Analyze the Site Assessment Information

There are several places to start analyzing this information. Areas of little concern will likely be obvious, as will plants or areas that are especially important.

- Identify key plants in the landscape. These are plants that play more important roles than others in the appearance, design or use of the landscape. For example, turfgrass is obviously a key plant in a park with a playing field.
- Look for opportunities to replace the turf species in problem areas. Notes on plant health and past history of pests may highlight turf species that could be replaced, either now or in the future. For example, if the creeping bentgrass on a shady green thins every year, supine bluegrass could be seeded to alleviate this problem, and velvet bentgrass could be used where pesticide use is restricted.
- Look for opportunities to make changes to the site design or facilities that would reduce the long-term cost of managing pests. For example, where people continually wear a path through a section of turf, bare patches are left open to invasion by weeds. This could be addressed by installing a permanent barrier to stop the foot traffic or by laying a pathway with a durable surface.
- Identify pest problems (i.e., broadleaf weeds or red thread disease in turf) that can be managed by improving the cultural conditions.
- Pick out sites where user patterns, environmental concerns or other factors would rule out the use of certain types of treatments. For example, herbicides would be ruled out where there is a high risk of chemicals moving off-site into a stream. Using flamers to control weeds would be ruled out in a high fire hazard area.
- Pick out sites well suited to particular treatments.

6. Draft a Site-Specific IPM Program

General IPM programs for the most common types of sites and pest problems in Ontario turf are outlined in subsequent chapters of this manual (other useful references are listed at the end of this chapter). Using these as a guide, along with the background information and site assessment information, work through the steps of an IPM program described in this chapter. Look at this as a flexible, working plan, which will be changed and improved over time.

Here are some suggestions from IPM professionals to help you get started:

Identification

- Establish a policy that ensures that every pest or plant injury problem is recorded and that no treatment action is taken until the problem has been identified.
- Start an identification collection and continue to add specimens over time. This might include a photograph collection as well as actual specimens of insects and pressed weeds. If possible, keep duplicate specimens or photographs of any sam-

ples you send to professional identification services; that way you have your own correctly identified specimen for your collection.
- Start a reference library that can be used to look up information about pests, plant health care, treatments and controls. Collect reference books, journals, pamphlets; set up information binders or files of reprints, magazine articles and other notes.

Monitoring

- With knowledge of the expected pests on the site and the key plants, draft a monitoring program for pests on those plants, taking into account the time of year that the pest problem is expected. For specific monitoring techniques for turf, see OMAF Publication 162, *Diseases and Insects of Turfgrasses in Ontario*.
- Choose a monitoring method and draw up a record sheet so that it is easy for the person doing the monitoring to record results. While all the basic information should be recorded, don't make the record sheet too complicated — if it is hard to use, mistakes will be made or the information may not be entered at all. See Appendix A, *Turf Scouting Record*, on page 79, Appendix B, *Golf Course Pest Scouting Form*, on page 81, and Appendix C in OMAF Publication 162, *Diseases and Insects of Turfgrasses in Ontario*, for examples.
- Set up a filing or record management system so that information on each site is easy to find and use. This would include site maps, monitoring records, injury thresholds and treatment information for each site.

Note: A table of insect monitoring methods and timetables is included in the OMAF Publication 162, *Diseases and Insects of Turfgrasses in Ontario*. The section *IPM Templates*, on page 17, also includes information on timing of pest monitoring and treatment.

Thresholds

Taking into account the objectives, users and category of each site, set injury levels or action thresholds for the pest population. To start with, these may simply be a best guess, based on experience or on information in publications (for suggestions, see the sections titled *Thresholds* in Chapters 4 to 6). You may also carry out practical research of your own to work out injury levels, such as for an acceptable percentage of weed cover. Review your thresholds regularly (usually annually) to fine-tune them in light of experience. When treatments are decided upon, use information about how the treatment works to decide when it will be used, and set treatment thresholds. Thresholds mentioned in this manual and OMAF Publication 162, *Diseases and Insects of Turfgrass in Ontario*, are guidelines or starting points only and should not be followed to the letter.

Controls

- Establish a policy on preferred treatments — what will be used and in which cases — and make sure everyone involved is aware of it. For example, list acceptable pesticides and methods of application and post the list where it is easy to see.
- Have the preferred products in stock so you can act immediately if monitoring shows that the thresholds for treatment have been reached. This will ensure that the intended product will be used, rather than something else that happens to be on hand. For biological controls, contact suppliers well beforehand, to find out about availability, recommendations on use and shipping arrangements.
- Order special tools, such as pheromone traps or headband magnifying lenses; locate and buy equipment, such as flamers or infrared weeders, super-heated water applicators for weeds in patios, etc., or special pesticide applicators and bait stations.

Evaluation

- Establish a schedule for evaluating the effects of treatments.
- After the busy season is over, schedule an IPM review to evaluate the results of your efforts and plan for next year's improvements. Include monitoring records, financial accounts and feedback from staff, as well as clients or site users.

7. Revise the IPM Program

Revisit your objectives and, as you gain experience and confidence, widen the scope of your IPM program to include more sites, other pests and additional techniques. With each year of experience you will be able to:

- improve monitoring methods and record sheets
- refine injury and action thresholds
- identify equipment you need to modify or purchase
- determine and act on staff training needs

IPM TEMPLATES

Table 2–1, *IPM Lawn Care Template*, below, Table 2–2, *IPM Golf Course Template*, on page 19, and Table 2–3, *IPM Sports Fields Template*, on page 24, outline examples of IPM programs for the various turf uses in Ontario. They take into consideration the major pests that attack turf in Ontario and suggest timing for monitoring, pest control and cultural practices such as fertilizing, aeration and irrigation.

TABLE 2–1.
IPM Lawn Care Template
✓ — monitoring X — treatment or application

Pest /Cultural Controls	Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter
European chafer and Japanese beetle *Rhizotrogus majalis* and *Popillia japonica*	✓ Check for grub damage.	X Treat with Merit if there is significant damage from the previous year in your area and if there are large adult flights.		✓ If not treated, monitor with cup changer. X Treat curatively if grubs are present. Consider using nematodes instead of insecticides.	✓ Monitor to determine treatment success.		Promote IPM to customers. Try to get customers as partners. Educate them on cutting and watering. Explain that the IPM approach will reduce pesticide use.
Hairy chinch bug *Blissus leucopterus hirtus*			✓ X Treat if chinch bugs present.				
Sod webworm *Crambus* sp. and *Chrysoteuchia topiaria*					✓ X Treat if sod webworm present.		
European cranefly *Tipula paludosa*	✓ X Monitor and treat if leatherjackets present.					✓ X Monitor and treat if leatherjackets present.	
Post-emergence broadleaf weed control (Do not mow or irrigate for 24 hours after treatment.)		✓ X Spot spray.			✓ X Spot spray (preferred timing).		

TABLE 2–1.
IPM Lawn Care Template (continued)
✓ — monitoring X — treatment or application

Pest /Cultural Controls	Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter
Pre-emergence crabgrass control	X Treat areas where infestation was mapped out the previous summer (usually in full sun, near driveways and roadsides).				✓ Map crabgrass infestation. If significant, treat with pre-emerge in spring.		
Post-emergence crabgrass control			✓ X Spot spray only if necessary.				
Diseases Turf diseases are treated with cultural practices. Fungicides are not recommended for home lawns.	Assess snow mould damage, rake to encourage the turf to dry up and fertilize lightly to encourage recovery.	Monitor for leaf spot, especially in excessively wet springs followed by hot, humid conditions. Raise mowing height and fertilize lightly to encourage recovery. Avoid heavy applications of nitrogen in early spring to minimize leaf spot and melting out.	Monitor for necrotic ring spot. If it is a problem, aerate and overseed with perennial ryegrass in the late summer/ early fall.	Continue monitoring for necrotic ring spot. Follow cultural practices in previous column. Monitor for dollar spot. Fertilize if dollar spot becomes a problem.	Monitor for rust. If rust is a problem, fertilize turf. Avoid fertilizing from mid-September to mid-October.		
Fertilization (N-P-K) Nat 0.5 kg/N per 100 m^2. P and K to be established by soil tests.		X	X Only if lawn is irrigated regularly or in a wet season.	X		X Late October–early November	
Mowing	Mow as high as possible. Do not remove more than one-third of the leaf blade with each mowing.						
Irrigation	Irrigate turf at least once a week with 2.5 cm of water if there is insufficient rainfall to keep turf from going dormant. Irrigation will help turf withstand grub feeding.						
Overseeding				X If turf has been damaged by diseases or insects			
Aeration		X		X			

TABLE 2–2.
IPM Golf Course Template
✓ — monitoring X — treatment or application

Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter (Nov–April)
Insects						
European chafer and Japanese beetle *Rhizotrogus majalis* and *Popillia japonica* Well-irrigated, well-fertilized turf can withstand more grubs than a site that is not irrigated.						
✓ Check for grub damage.	X Treat with Merit if there is significant damage from previous year and there are large adult flights.		✓ If not treated, monitor with cup changer. X Treat curatively if grubs present. Consider using nematodes instead of insecticides.	✓ Monitor to determine treatment success.		
Black turfgrass ataenius *Ataenius spretulus* Well-irrigated, well-fertilized turf can withstand more grubs than a site that is not irrigated.						
✓ Monitor for adults in clipping baskets or with a soap flush when Van Houtte spirea and horse chestnut are in full bloom.	✓ X Monitor for young grubs using a cup cutter. Concentrate on collars and edges of fairways near areas of high adult populations in early spring. X Spot treat areas where grubs are found.					
Annual bluegrass weevil *Hyperodes maculicollis*						
✓ Monitor for adults returning to turf when forsythia are in full bloom.	✓ Monitor annual bluegrass collars, tees and fairways using a cup cutter. X Treat if larvae are found.					
Black cutworms *Agrotis ipsilon*						
	✓ Monitor using a soap flush, especially after aeration. X Treat if large numbers are found and damage is occurring.					

TABLE 2–2.
IPM Golf Course Template (continued)
✓ — monitoring X — treatment or application

Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter (Nov–April)
Sod webworm *Crambus* sp. and *Chrysoteuchia topiaria*						
				✓ X Monitor greens using a soap flush and treat if sod webworms are present.		
European cranefly *Tipula paludosa* A well-maintained turf can withstand higher larval populations than a poorly maintained turf.						
✓ X Treat if large numbers of leatherjackets are found.					✓ X Monitor if large adult flights occurred in September and treat if leatherjackets are present.	
Diseases						
Grey snow mould *Typhula incarnata* and *Typhula ishikariensis* Composts have been shown to suppress grey snow mould. Avoid heavy N application in early fall. Late fall fertilization is OK. Maintain adequate K levels in fall and avoid compaction.						
✓ Occurs under snow after 90 days of snow cover.						X Preventative funigicide application can be made just before snow fall where grey snow mould is a problem.
Pink snow mould *Microdochium nivale* Avoid heavy N application in early fall. Late fall fertilization is OK. Maintain adequate K levels in fall and avoid compaction.						
✓ Occurs under snow cover after 7–10 days from November through March.						X Composts have been shown to suppress pink snow mould. X Preventative funigicide application can be made just before snow fall where pink snow mould is a problem.

TABLE 2–2.
IPM Golf Course Template (continued)
✓ — monitoring X — treatment or application

Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter (Nov–April)
Fusarium patch *Microdochium nivale* Avoid excess N, remove dew.						
✓ Monitor for disease in March, April, May, when cool, wet conditions exist. X Treat if symptoms persist.				✓ Monitor for disease when cool, wet conditions exist. X Treat if symptoms persist.		
Yellow patch *Rhizoctonia cerealis* Avoid excess N, improve drainage and air circulation.						
✓ Monitor if cool, wet conditions exist. X Treat if symptoms persist.				✓ Monitor if cool, wet conditions exist. X Treat if symptoms persist.		
Leaf spots and melting out *Bipolaris* and *Curvularia* species Avoid close mowing and heavy N application in spring.						
✓ April–June Rarely a problem on bentgrass golf courses. Mainly attacks Kentucky bluegrass.				✓ September–October Rarely a problem on bentgrass golf courses. Mainly attacks Kentucky bluegrass.	✓	
Dollar spot *Sclerotinia homoeocarpa* Composts have been shown to suppress dollar spot. Remove dew, apply adequate N, frequent, lightweight rolling.						
		✓ Occurs June–September 21°C–27°C during periods of high humidity and leaf wetness. Monitor for the beginning of epidemics when iris and peony are in full bloom and lilacs in full-to-late bloom. X Treat when first signs of infection occur.	X Treat when favourable conditions occur.			

TABLE 2–2.
IPM Golf Course Template (continued)
✓ — monitoring X — treatment or application

Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter (Nov–April)
Brown patch *Rhizoctonia solani* Composts have been shown to suppress brown patch. Remove dew, avoid excess N and avoid over-irrigating. Reduce shade and improve air movement.						
	✓ Requires leaf wetness of 10 hr to develop, high nitrogen, temperatures 25°C–32°C and high humidity. Rarely causes extensive damage in Ontario. X If conditions favouring disease persist, a fungicide application may be necessary.					
Take-all patch *Gaeumannomyces graminis* Cool, wet conditions in spring favour this disease. It is found mainly on newly seeded bentgrass greens, tees and fairways with high soil pH.						
✓ Apply manganese October or April at 2.25 kg Mn/ha.		✓ 0.2 kg N/100 m^2 of ammonium sulphate			✓ Apply manganese October or April at 2.25 kg Mn/ha.	
Summer patch *Magnaporthe poa* Improve drainage, reduce compaction, avoid low mowing, fertilize with slow release fertilizers, irrigate infrequently and deeply and syringe.						
✓ Infections occur in late spring when soil temperatures are 18°C–20°C.	X Apply preventative fungicide application when soil temperature is >16°C at 5 cm depth for 4 consecutive days, with a second application 30 days later.	✓ If disease is present, treat preventively the following year.				
Anthracnose foliar blight *Colletotrichum graminicola* Avoid drought stress. Syringe turf between 10 am and 2 pm when temperatures exceed 27°C. Alleviate compaction, fertilize with N and avoid evening watering and raise mowing height.						
		✓ Requires temperatures > 25°C and high relative humidity. X Treat preventatively with fungicide if conditions ideal for disease to occur.				
Anthracnose basal rot *Colletotrichum graminicola* Symptoms associated with low height of cut, low nitrogen, wet soils and wounding of plant during aerification. Improve drainage, raise mowing height, cut back on aeration, apply frequent low rates of N.						
✓ Presently no fungicide controls are registered for this in Ontario.	✓	✓	✓	✓		

TABLE 2–2.
IPM Golf Course Template (continued)
✓ — monitoring X — treatment or application

Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter (Nov–April)
Pythium blight *Pythium aphanidermatum* or *Pythium ultimum* Avoid excess N, improve drainage, improve air circulation. Do not over-irrigate.						
		✓ During period of high temperature (>27°C day and >20°C night) X Treat preventatively if favourable conditions are forecast.				
Post-emergence broadleaf weed control (Do not mow or irrigate for 24 hours after treatment.)						
	✓ X Spot spray.			✓ X Spot spray (preferred timing).		
Fertilization (Greens) (N) P and K to be established by soil tests						
	X .15–.35 kg/100 m^2/month				X .25–.35 kg/100 m^2 (late October)	
Fertilization (Tees) (N) P and K to be established by soil tests						
	X .15–.5 kg/100 m^2/month				X .25–.5 kg/100 m^2 (late October)	
Fertilization (Fairways) (N-P-K) P and K to be established by soil tests.						
	X .25 kg/100 m^2/month				X .25 kg/100 m^2 (late October)	
Mowing	Mow as high as possible. Do not remove more than one-third of the leaf blade with each mowing.					
Irrigation	Irrigate turf as needed. Do not overwater, as this encourages diseases. Irrigate in the early morning to avoid long periods of leaf wetness.					
Overseeding						
X Treat if turf has been damaged by disease or winter injury.			X Treat if turf has been damaged by diseases or insects.			
Topdressing	Topdress frequently and match the growth rate of the turf, i.e., topdress more frequently in the fall and spring when turf is growing rapidly (every 2–3 weeks) and less often in the summer months as growth slows.					
Aeration	X	Consider water injection aerification during summer months.		X		

TABLE 2–3.
IPM Sports Fields Template
✓ — monitoring X — treatment or application

Pest/Cultural Controls	Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter
European chafer and **Japanese beetle** *Rhizotrogus majalis* and *Popillia japonica*	✓ Check for grub damage.	X	Treat with Merit if there is significant damage from the previous year and large adult flights this year.	✓ If not treated, monitor with cup changer. X Treat curatively if grubs are present. Consider using nematodes instead of insecticides.	✓ Monitor to determine treatment success.		
Hairy chinch bug *Blissus leucopterus hirtus* Rarely a problem on sports fields.			✓ X Treat if chinch bugs present.				
Sod webworm *Crambus* sp. and *Chrysoteuchia topiaria*					✓ X Treat if sod webworm is present.		
European cranefly (leatherjackets) *Tipula paludosa*	✓ X Monitor and treat if leatherjackets are present.					✓ X Monitor and treat if leatherjackets are present.	
Post-emergence broadleaf weed control (Do not mow or irrigate for 24 hours after treatment.)		✓ X Spot spray.			✓ X Spot spray (preferred timing).		
Pre-emergence crabgrass control	X Treat areas where infestation was mapped out the previous summer.				✓ Map crabgrass infestation. If significant, treat with pre-emerge in spring.		

TABLE 2–3.
IPM Sports Fields Template (continued)
✓ — monitoring X — treatment or application

Pest/Cultural Controls	Early Spring (May)	Late Spring (June)	Summer (July)	Late Summer (August)	Fall (September)	Late Fall (October)	Winter
Post-emergence crabgrass control			✓ X Spot treat where necessary.				
Diseases Turf diseases are treated with cultural practices – fungicides are rarely recommended for sports fields.	Assess snow mould damage, rake to encourage the turf to dry up and fertilize lightly to encourage recovery.	Monitor for leaf spot, especially in excessively wet springs followed by hot, humid conditions. Raise mowing height and fertilize lightly to encourage recovery. Avoid heavy applications of nitrogen in early spring to minimize leaf spot and melting out.	Monitor for necrotic ring spot. If it is a problem, aerate and overseed with perennial ryegrass in the late summer/ early fall.	Continue monitoring for necrotic ring spot. Follow cultural practices in previous column. Monitor for dollar spot. Fertilize if dollar spot becomes a problem.	Monitor for rust. If rust is a problem, fertilize turf. Avoid fertilizing from mid-September to mid-October.		
Fertilization (N-P-K) N at 0.5 kg per 100 m^2. P and K to be established by soil tests.		X	X Treat only if field is irrigated regularly or the season is wet.	X	X Treat before September 15.	X late October	
Mowing	Mow as high as possible. Do not remove more than one-third of the leaf blade with each mowing.						
Irrigation	Irrigate turf at least once a week with 2.5 cm of water if there is insufficient rainfall to keep turf from going dormant. Irrigation will help turf withstand wear and grub feeding.						
Overseeding		X	X	X	X Treat if turf has been damaged by diseases or insects.		
Aeration		X	X	X	X		

MANAGE FOR SUCCESS

To organize a successful IPM program in a company or agency with a number of employees, it is important to manage people so that they have the time, skills and resources to do the job well.

- Make a commitment to the IPM project by making sure someone is specifically in charge of seeing that planned IPM work gets done.
- Involve all staff so they know who has what responsibilities, where to find information, etc. Keeping everyone informed, including "front office" staff, helps them deal with clients and the public regarding IPM.
- Allow enough time for staff to do the monitoring and keep records, perhaps, by setting aside specific time for monitoring. Monitoring may not get done if staff are expected to add it onto other work without allowing extra time to do it. Allow for the fact that monitoring usually takes longer at first. It will take less time as people become more skilled and the monitoring program is refined with experience.
- Make sure that staff are trained and know how to perform the work, whether it is monitoring, keeping records or using new treatment methods.
- Invest in reference materials, subscriptions to IPM publications and professional publications for use by staff (suggested basic references are listed under *References* at the end of each chapter of this manual).

EDUCATE AND COMMUNICATE

An essential part of an IPM program is communication. Although good communication between staff and with clients or site users is always desirable, it is particularly important when making changes to the way you do things. Although IPM methods are well established among turf professionals in Ontario, it can still feel risky to someone trying to adopt IPM methods for the first time. So get to know other turf professionals and learn from them. Involve your staff or your co-workers in the whole project and take advantage of their interest and enthusiasm to make it work. Let your clients or site users know what you are trying to do. Communicate that efforts in pest monitoring may likely require more staff and hence increase budgets initially.

Above all, don't forget to promote IPM initiatives. Whether it is through a newsletter to your clients, golf course members or a public brochure for municipal park users, let people know about your IPM practices. As a result of such promotion, companies often receive favourable coverage in the local press — a great way to boost business.

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3. Pest Management Recommendations

Treatments that suppress pests, while presenting the least risk to applicators and site users and doing the least harm to the environment, are preferable to those that have more toxic or broad-spectrum effects. Mechanical, physical and biological control agents (natural enemies) usually fit this description, as do some registered pesticides.

CULTURAL CONTROLS/CULTURAL PRACTICES

Cultural practices or cultural controls are discussed in detail in the section *Management*, on page 2.

Biostimulants

The growth and development of turfgrasses can be suppressed by various environmental stresses, such as drought stress, saline stress, etc. Environmental and cultural stresses can limit the natural production of plant hormones, specifically cytokinins. Any time a plant goes into stress, it can stop producing cytokinins and other hormones required for general vigour. As a result, the turfgrasses grown under drought stress have poor quality, high disease incidence and low survival.

Research has indicated that biostimulants, when applied to plants, can stimulate growth and metabolism and improve plant resistance to stress environments. These biostimulants include hormones (auxin, cytokinin, etc.), vitamins, organic acids, chelating agents, enzymes, coenzymes and triazole compounds that supplement the plant's own hormone system. Treated and untreated grass may look the same under normal growing conditions, but a biostimulant enhances turf so that it has increased stress tolerance. In other words, plants can be conditioned to withstand stress, be it natural or man-made.

Recent studies have shown that foliar applications of cytokinin-like growth regulators can enhance root growth and increase plant resistance to environmental stresses, such as drought stress. Treated grass avoids going into a stress reaction and recovers from stress quicker and in better condition. It has a higher degree of tolerance for drought or excessive moisture and makes more efficient use of irrigation water and commercial fertilizers.

The attraction of using biostimulants is twofold — economic and ecological. They are relatively inexpensive and organic. As well, they may provide a way to reduce commercial fertilizer use, while cutting down on other chemicals such as fungicides, herbicides and pesticides.

Turfgrass Species

Selecting the appropriate turfgrass species is also an important part of an IPM cultural program. A summary of turfgrass species characteristics can be found in Table 1–1, *Turfgrass Species Characteristics and Recommended Uses*, on page 3. More detailed information is also available in Chapter 5 of OMAF Publication 384, *Turfgrass Management Recommendations*.

Velvet Bentgrass

Although velvet bentgrass has not been widely used in recent years, there has been renewed interest in it due to its tolerance to disease, shade and stress.

Velvet bentgrass has the finest leaf texture, highest shoot density and smoothest playing surface of all turfgrasses, including the creeping and colonial bentgrasses. Velvet bentgrasses possess exceptional drought, shade and disease tolerance while requiring very low levels of nitrogen fertility. They also have good wear-stress tolerance and, according to some researchers, better heat tolerance than was once considered.

Overall Turf and Putting Surface Quality It has long been known that velvet bentgrasses are the most visually striking turfgrasses, having the most luxurious, green velvet surface of all the turf-type grasses. Furthermore, velvet bentgrass greens are most often the smoothest, truest, fastest putting surfaces a golfer will encounter.

Density Velvet bentgrasses have the finest texture of all the turfgrasses, leading to an extremely high numbers of shoots per unit area. The density of velvet bentgrass is much greater than creeping bentgrasses and higher than equivalent stands of annual bluegrass.

Colour There is much diversity of colour within the velvet bentgrasses, ranging from very light to a bright, lime green and often darker.

Tolerances Velvet bentgrasses have a very high drought tolerance compared to creeping bentgrasses. There also exists a high degree of wear tolerance within species. Of all the bentgrasses, the velvets routinely show the highest tolerance of shady conditions. Also, velvet bentgrasses have good low-temperature tolerance. High-temperature tolerance has always been considered its major limitation.

Disease Resistance These grasses also generally have high resistance to most turfgrass diseases. SR 7200 has been shown to have excellent resistance to dollar spot and brown patch. It has shown good resistance to fusarium patch. Mature turf is highly resistant to *Pythium* sp. diseases but is susceptible at the seeding stage. Late-season seeding or using seed treated with Apron® (metalaxyl) will generally resist the seedling *Pythium* sp.

Fertility Velvet bentgrasses are well adapted to low-nitrogen fertility programs and will not perform well if maintained at levels considered necessary for creeping bentgrasses. Most successful velvet bentgrass management programs survive on less than 1.0 kg/100 m^2 of N per year, although sand-based greens may take upwards of 1.5 kg/100 m^2 of N per year. These nitrogen applications are generally in an ammoniacal form of nitrogen in a very small particle size granule (<SGN 100) or as foliar-applied, soluble fertilizer. Organic nitrogen sources are invaluable to successful velvet bentgrass management due to their lower salt indexes and capacity to nourish soil microorganisms.

Soil pH Levels Although velvet bentgrasses are adapted to relatively low soil pH levels (5.0–5.5), they persist and perform better at slightly acidic levels of 6.0–6.5. In neutral soils (7.0) or soils near to neutral (6.5–7.5), acidifying fertilizers such as ammonium sulphate improve the performance of velvet bentgrass.

TABLE 3–1.
Comparison of Velvet Bentgrass and Creeping Bentgrass

Characteristic	SR 7200	Providence
Shoot density May 1997 (close mowing - 5 mm)	245, 756	87,828
Fineness of leaf (mm)	0.52	0.73
Brown patch (LSD 1.5)[1]	6.7	4.3
Dollar spot (LSD 1.2)[1]	8.7	7.3

[1] 1 is low resistance and 10 is high resistance.

Mowing Heights Velvet bentgrasses are much more accommodating of low mowing heights than was once thought. Heights as low as 3.00 mm (0.120 in.) are fairly common on tournament-grade velvet bentgrass greens. Similarly, velvet bentgrasses can be mown at comparatively higher heights of cut while retaining extremely smooth putting surfaces (4.00 mm or 0.156 in.). Similarly, velvet bentgrass performs very well at fairway heights to 14.00 mm (0.560 in.).

Thatch Management Left unmanaged, the thatch produced by velvet bentgrasses can become problematic. Frequent, light topdressing coupled with light vertical mowing will help maintain a firm, smooth surface. Aggressive, deep verticutting may be needed once a year to remove hydrophobic thatch, and deep-tine aerification may be necessary to relieve compaction on native soil greens. Test topdressing materials for particle sizing before application to prevent poor water infiltration issues.

It is apparent when comparing the positive to negative aspects that the velvet bentgrasses have a decided advantage over creeping bentgrasses when considering low-input or IPM programs. There have also been numerous reports, although not scientifically reported, that velvet bentgrasses compete very successfully with annual bluegrass, especially when managed at reduced irrigation frequencies, low fertility and low-profile pH values. In fact, soil pH levels can be reduced using ammonium fertilizers to levels that actually inhibit annual bluegrass germination, while at the same time promoting velvet bentgrass. For those who wish to eliminate annual bluegrass infestations, velvet bentgrass may be the logical choice, particularly under shaded areas that suppress creeping bentgrass.

MECHANICAL AND PHYSICAL CONTROLS

Heat Treatment for Non-Selective Vegetation Control

Various systems have been invented to deliver high temperatures to kill the foliage of plants. They include:

- Flamers, which have been in use for over 50 years. Several sizes of handheld propane torches are available, as well as tractor-mounted flamers. Flamers produce temperatures of about 900°C.
- Hot water or low-pressure steam applicators, which have become more widely available since the early 1990s. Most are large pieces of equipment, mounted on trucks or trailers. However, development of smaller and handheld models continues. These deliver 100°C–200°C water or steam to plant surfaces.
- Infrared radiation applicators, which burn propane fuel to produce a radiant heat source. Equipment now available ranges from handheld applicators for spot treatments of dandelions to hand-propelled and tractor-mounted units for broader treatments.

Various models of the heat applicators described above are sold or leased by suppliers. Some service companies purchase the equipment and provide treatments on a contract basis. Much of this equipment is large and more suited to municipal or industrial use, however, handheld flamers are widely available. Small infrared applicators have recently become available in Canada.

Mode of Action High temperatures tear apart plant cells and destroy proteins in the cells. It is only necessary to heat the leaf long enough to destroy the waxy cuticle of the leaf and disrupt the cells. Torching or boiling the plants until damage can be seen immediately is unnecessary and may stimulate regrowth of some established perennials. Effects of heating may be visible in as little as an hour or take up to several days to show.

Seedlings, annuals, young perennials and germinating seeds are most susceptible to heat damage. They are usually killed by a single treatment. None of the heat treatments penetrate into the soil or below a layer of gravel, therefore they do not kill the roots of established perennials. Perennials may require three or more treatments in a season to deplete the roots and kill the plant.

Broadleaf weeds are more easily damaged by heat than grasses are. The growing tips of grasses are encased in a heat-resistant sheath, which makes it possible to selectively control weeds in turf using a flamer (practice your technique in a low-visibility area first).

Use Using heat to control vegetation is ideal where non-selective control is required, such as:

- hard surfaces where any plant growth is undesirable (i.e., gravelled areas, cracks in sidewalks and pavements)
- where all vegetation must be kept very short (i.e., around fire hydrants, sign posts, utility poles, metal sprinkler heads and along fence lines)
- for marking lines on playing fields and ball diamonds, using a narrow applicator head

Where flamers are used, the risk of causing a fire or damaging plastic fittings, such as sprinkler heads, must be taken into account. When using the flamer, direct the hottest part of the flame (the cone-shaped area around the flame) at the weeds. Hold the nozzle above the plant and slowly pass it over once.

Plants in dry conditions appear to be more susceptible to heat treatments than in cool and moist conditions. Weeds are most susceptible to heat when less than a few centimetres tall (the 4–5 leaf stage). This stage is when the roots are also killed by the heat treatment. Under moist conditions, several treatments may be needed annually: one in spring to kill the majority of seedlings, followed by a treatment after fall rains cause another flush of germination. Regular treatment prevents establishment of perennials.

BIOLOGICAL CONTROLS (NATURAL ENEMIES)

Beneficial Insects

The reproductive powers of many insects are enormous. Several can lay hundreds of eggs, producing multiple offspring in their lifetime or rapidly develop and have multiple generations during the growing season. Predatory insects can also be very abundant in turf. Surveys have revealed dozens of species of ants, ground beetles, spiders, rove beetles and other groups that mainly feed on the eggs or

active stages of plant-eating insects and readily consume large numbers of eggs and larvae. Naturally occurring parasitic insects, including tiphiid, braconid and ichneumoid wasps, tachinid flies and other groups may also be abundant in turf. The fact that outbreaks of pests are uncommon in low-maintenance turf suggests that most pests are normally held in check by natural buffers. Much of the evidence for this comes from accounts of pest outbreaks at turf sites where natural enemies had been inadvertently eliminated by broad-spectrum insecticides.

Spiders (Arachnida: Araneae)

Spiders are often abundant in turfgrass. All species are predatory, feed mainly on insects and kill their prey by injecting venom as they bite. Some kinds of spiders make small webs in the grass; others are free-living, relying on ambush or speed to capture their prey. See Figure 3–1, right.

Ground Beetles (Coleoptera: Carabidae)

Ground beetles are fast-moving, beneficial insects that are abundant in turf. Both the adults and the soil-inhabiting larvae prey on eggs or larvae of insects, and some species may be important in reducing populations of sod webworms, white grubs or other pests. See Figure 3–2, right.

Rove Beetles (Coleoptera: Staphylinidae)

Rove beetles are fast-moving, slender, elongate, dark-coloured insects that can usually be identified by the very short elytra that leave much of the abdomen exposed beyond their apices. Most species are predaceous and beneficial. See Figure 3–3, right.

Big-Eyed Bug (Hemiptera: Lygaeidae)

Big-eyed bugs are important predators of hairy chinch bugs. They possess piercing, sucking mouth parts that allow them to feed on the liquid contents of chinch bugs. Big-eyed bugs resemble chinch bugs but are more robust and have large eyes that protrude out of the side of their head. They also move more rapidly than chinch bugs. See Figure 3–4, on page 31.

Ants

Ants are mostly beneficial because they prey on the eggs and active immature stages of pest insects. They may play an important role in helping buffer turfgrass against pest outbreaks. Ants are sometimes troublesome, especially on and around golf greens,

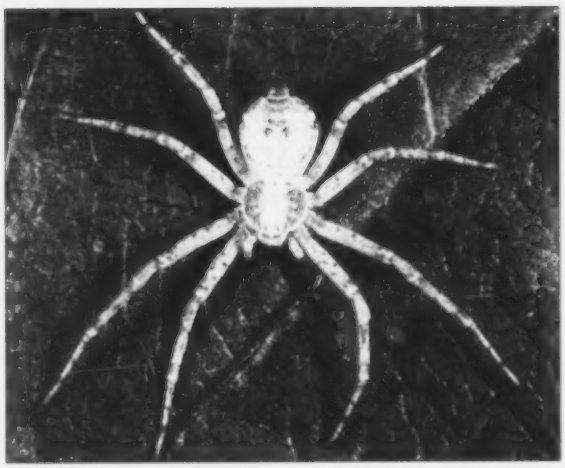

FIGURE 3–1. Spider.

FIGURE 3–2. Ground beetle.

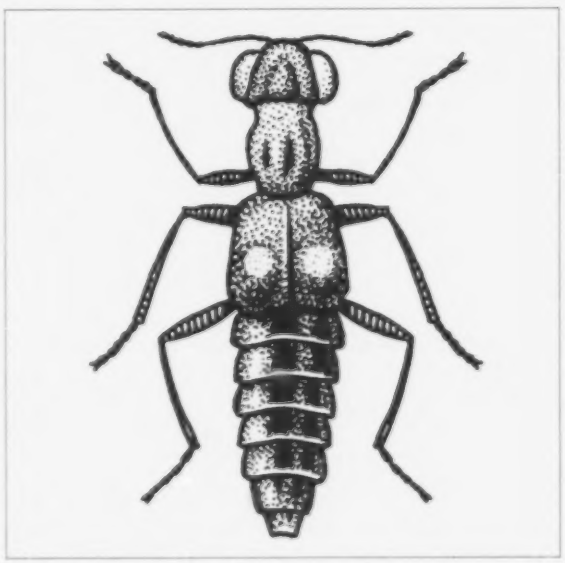

FIGURE 3–3. Rove beetle.

FIGURE 3–4. Big-eyed bug preying on a hairy chinch bug nymph.

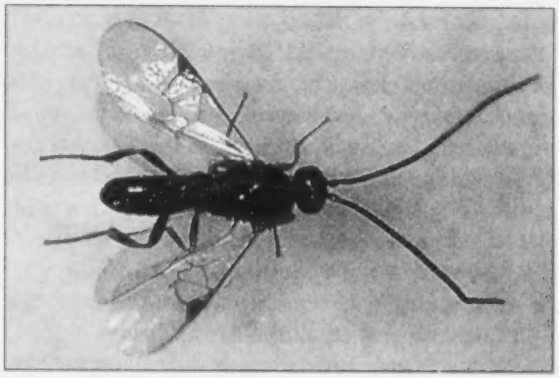

FIGURE 3–5. Wasp.

because the mounds they build interfere with the putting surface.

Wasps (Hymenoptera)

Wasps of several families that are sometimes observed hovering over turfgrass in the spring or fall are parasitic on pest insects. The *Scoliidae* are relatively large, hairy, dark-coloured wasps with yellow or orange markings on the abdomen. Larvae of these wasps are external parasites of white grubs; the adults are often found on flowers. *Tiphiidae* are somewhat smaller black-and-yellow wasps that parasitize the larvae of Japanese beetles and other scarabs. Females of both groups search out a grub in the soil, sting it to paralyze the grub temporarily and then deposit an egg on the host. Upon hatching, the maggot-like larva attaches itself externally to the white grub, pierces the host's cuticle with its mouthparts and feeds upon the body fluids, ultimately killing the grub. Rates of parasitism of 80% or more have been observed at some sites. See Figure 3–5, right.

Centipedes (Chilopoda)

Centipedes are fast-moving predators that feed on insects and spiders.

Earthworms (Oligochaeta: Lumbricidae)

Earthworms feed mainly at night on organic matter on or in the soil. Golf superintendents or landscape managers sometimes regard earthworms as a nuisance because their habit of depositing soil on the turf surface as "castings" can disrupt the smoothness and uniformity of greens or other fine turf.

Earthworms mix organic matter into the soil and fragment and condition plant debris in the gut before bacteria and fungi further break it down. Decomposition of thatch is usually much faster when earthworms are abundant. The burrowing activity of earthworms enhances soil structure and is critical for air and water infiltration. Two-thirds of the total pore space in soils may consist of earthworm tunnels.

The presence of earthworms has been shown to enhance the growth and yield of grass in pastures. Excessive thatch causes long-term problems with reduced water infiltration, restricted penetration of insecticides and fertilizers, shallow rooting and greater vulnerability to heat and drought stress. Thatch is rarely excessive where earthworms are abundant. They play an important role in breaking apart and decomposing thatch and in improving its physical and chemical properties for the growth of turfgrass.

Pesticides used on turf differ markedly in their toxicity to earthworms. Some products can cause severe and long-lasting reductions in earthworm populations, even when applied at labelled rates. Earthworms and white grubs are a preferred food for moles, and, as a result, pesticides are sometimes applied in the hope of reducing the food supply and causing the moles to go elsewhere. There is, however, no scientific evidence that elimination of earthworms will alleviate a problem with moles. Considering the importance of earthworms in aerating and enriching the soil, enhancing water infiltration and breaking down thatch, turfgrass managers would be advised to conserve worm populations whenever possible.

Mites (Arachnida: Acari)

Mites, specifically oribatids (*Cryptostigmata*), inhabit soils under turfgrass. They are tiny, rounded or pear-shaped, dark-coloured creatures that feed upon fungi and decaying organic matter and contribute to the decomposition of plant litter and nutrient recycling in turf. Long-legged mites help reduce populations of plant-feeding mites and may also prey on the eggs of pest insects such as sod webworms.

Commercial Biological Controls

Releasing commercially reared biological controls is a well-established method of controlling pests in greenhouses and interior plantscapes. There are over 20 species of beneficial insects and mites commonly sold for this. Only a few species, however, have been shown to be practical for releases outdoors. Generally, the most useful approach outdoors is conserving and attracting native beneficial species to act as biopesticides (as described in the section *Biological Controls*, on page 10).

The great advantages of using these biopesticides are in operator and end-user safety and the absence of re-entry periods. Furthermore, biopesticides are environmentally friendly and do not harm vertebrates. Nematodes kill pests quickly and can be introduced in a water solution using conventional sprayers currently in use by turf maintenance firms.

The commercial biological controls described below can be used in turf. Although microbial products are biological controls, they are also registered pesticides and, therefore, are discussed later in this chapter in the section *Pesticides*, on page 34.

Insect Parasitic Nematodes

Nematodes ("roundworms") are slender, tapering worms. There are thousands of species of nematodes; many attack plants, others break down organic matter, and there are beneficial species that attack insects. Although some nematodes are quite long (e.g., horsehair worms), most are microscopic. Among them are the insect parasitic nematodes.

To date, the nematodes available in commercial products have been species of *Steinernema* or *Heterorhabditis*, although others are under development.

Advances in rearing techniques have made it possible to produce them economically in large numbers, which has encouraged their commercialization.

They seek out and kill various insect pests and are used rather like insecticides. Insect-attacking nematodes have a life cycle consisting of an egg, four juvenile stages and the adult. Both species have a specialized, infective juvenile stage, which is the stage that attacks insects. It is non-feeding and thus can survive in the soil for extended periods until it is able to find a susceptible host.

Nematodes find hosts by detecting the hosts' carbon dioxide and excretory products. Infective juveniles enter hosts through natural openings, such as the mouth, anus or breathing pores. These nematodes carry specific bacteria in their intestines. When the nematode enters the host insect, the nematode releases bacteria into the host, where they rapidly multiply. The bacteria kill the host by releasing protein-destroying enzymes, usually within 24 hours. Nematodes feed on the host remains and complete two or three generations inside the host. When the host's insides are gone, large numbers (up to 100,000) of infective juveniles leave the host and begin to search for new hosts. At room temperature (21°C), it takes *Steinernematid* nematodes about 7–10 days from infection to the emergence of new infective nematodes. *Heterorhabditid* nematodes take about 12–15 days. As their range of insect hosts is quite wide, nematodes can be used against many pest species. Furthermore, nematodes are tolerant of spray pressures up to 2,000–2,800 kPa and may be field applied with standard spray equipment. Nematodes are not affected by many insecticide compounds and may be incorporated into ongoing turf IPM programs.

Target Pests Various species of insect parasitic nematodes can be used to control the larvae of root weevils, craneflies (leatherjackets), fungus gnats and other turf pests. Generally, *Steinernema carpocapsae* is better suited to webworms, cutworms, girdlers and wood-borers, while *S. feltiae* is more suited to fly larvae. Other species particularly suited to control white grubs and other root weevils may become available in the future.

In a study conducted at Laval University in Quebec, it was found that the nematode species *Steinernema glaseri* was the most virulent against European chafer larvae. It should be noted that *Steinernema glaseri* is not commercially available. The ability of *S. glaseri* to infect its hosts is often attributed to its searching strategy, in that it "cruises" for immobile hosts. This

species was also most effective on European chafer larvae in sandy soil. The larger spaces in sandy soil likely make it easier for the nematode to move about and find its host. In addition, European chafer mortality was highest at high soil-moisture levels.

Studies indicate that very high concentrations of nematodes are necessary for acceptable levels of European chafer control. Certain strains of nematodes have been marketed for control of turfgrass insect pests. At the moment, the use of insect parasitic nematodes is not economically viable in comparison with currently registered insecticides. In urban settings, the diversity of soil types and soil moisture levels makes the use of nematodes more difficult. In a similar study, also conducted at Laval University, it was found that *Heterorhabditis megidis* and *Steinernema carpocapsae* were the most virulent species against cranberry girdler.

Use Nematodes are sold in a dormant stage so that they survive storage and shipping. To apply, mix the nematodes in water and apply them to the soil. They can also be applied through irrigation systems. Since products differ, always follow application instructions with the product. They will settle out in spray tanks if not agitated properly. Also, they need a water film to reach their targets. When applying to soil to treat various pests, the soil must be moist, though not too wet. Even though nematodes can move to seek out insect pests, they cannot go very far (a few centimetres), and the nearer you can get them to the insect, the more likely they are to be able to infect that insect. Good coverage is essential. After applying nematodes onto the soil surface or turf, irrigate immediately. This helps wash the nematodes down through the vegetation and into the soil. They are susceptible to ultraviolet light, so must be watered in to get them out of the sunlight.

As biologicals, nematodes are very sensitive to certain environmental factors:

- They break down in ultraviolet light.
- They dry out easily.
- They perform best between 12°C and 30°C.

Currently, nematodes have not been widely adopted for use by the turf industry because of their high cost and because the environmental conditions necessary to guarantee the success of the nematode treatments rarely exist.

Biological Insecticides

Spinosad is a new class of insecticide. It is derived from the soil actinomycete *Saccharopolyspora spinosa*. Spinosad utilizes naturally produced metabolites that work as well and as quickly as synthetic pesticides but it has a safety profile similar to biologicals.

Spinosad is a mixture of the two most active naturally occurring metabolites, spinosyns A and D, which are produced by *S. spinosa*. A unique mode of action, coupled with a high degree of activity on targeted pests and low toxicity to non-target organisms (including many beneficial arthropods) make spinosad an excellent new tool for the management of insect pests.

Spinosad is derived from the fermentation of *S. spinosa*. Following fermentation, spinosad is extracted and processed to form a concentrated liquid suspension that is easy to use and distribute. It is stable for 28 days and has a shelf life of 3 years as formulated material.

The degradation of spinosad in the environment occurs through a combination of routes, primarily photodegradation and microbial degradation to its natural components of carbon, hydrogen, oxygen and nitrogen. The leaching potential of spinosad is very low due to low-to-moderate water solubility and short residual in the environment. Thus, it does not pose a threat to groundwater when used properly.

Spinosad is relatively low in toxicity to mammals and birds and is only slightly toxic to fish. Spinosad exhibits wide margins of safety to many beneficial insects and related organisms. It has relatively low activity against predaceous beetles, sucking insects, lacewings and mites. Spinosad demonstrates rapid contact and ingestion activity in insects, which is unusual for a biological product. The mode of action of spinosad is characterized by excitation of the insect nervous system, leading to involuntary muscle contractions, prostration with tremors and paralysis. Check OMAF Publication 384, *Turfgrass Management Recommendations*, for the current registration status of spinosad.

Compost as a Disease Suppressant

The disease-suppressive characteristics of compost are due to the release of antibiotic compounds such as phenols and to the presence of bacterial and fungal microflora that suppress pathogens through

TABLE 3–2.
Microbial Characteristics Influencing Disease Suppression With Composts

Mechanism of Suppression	Description
Nutrient competition	Microbial activity out-competes pathogens for nutrients, preventing their growth and germination.
Antibiosis	Organisms are inhibited by metabolites of micro-organisms; may be a survival or competition mechanism.
Lytic and other extracellular enzymes	Enzymatic compounds are produced by a variety of microorganisms to decrease growth and survival of others; often done to decrease competition for nutrients, space and other factors.
Parasitism and predation	Mycoparasites can reduce the concentration of inoculum of a pathogen by enhancing degradation of dormant propagules, interfering with their formation or inhibiting their germination.
Host-mediated induction of resistance	Micro-organisms or other chemical or physical factors in organic amendments can promote plant growth or induce plants to produce certain enzymes related to defence mechanisms.

antagonism and competition. Biocontrol agents that colonize compost include bacteria such as *Bacillus, Enterobacter, Flavobacterium balusstinum* and *Pseudomonas*, actinomycetes such as *Streptomyces* and fungi such as *Trichoderma* and *Gliocladium*. In general, microbial antagonists control pathogens through a variety of mechanisms (e.g., competition, antibiotic secretions, predation and induced resistance). Some also function as plant growth promoters. See Table 3–2, *Microbial Characteristics Influencing Disease Suppression With Composts*, above. Naturally suppressive (antagonistic) composts can be incorporated into normal golf course, sports turf or home lawn maintenance by replacing sphagnum peat or other organic materials used in topdressing mixtures or in soil root-zone mixtures. Compared to peat, compost provides quicker greening of turfgrass, a more dense stand, reduction of thatch, increased earthworm activity and, especially, increased microbial activity. While compost may not control turf diseases to a level that will replace fungicides, its integration into current disease management practices may reduce the use of chemicals.

Research at the University of Guelph has shown that fall applications of compost provide good control of pink and grey mould. An application of 97.4 kg/100 m^2 gave the same level of control as the fungicide quintozene. In addition, compost-treated plots greened up more quickly than either the fungicide control plots or fertilizer-treated plots. Additional research at the University of Guelph has found that regular applications of Ringer Greens Super and Ringer Turf Restore significantly suppressed dollar spot. In these studies, however, they did not provide acceptable levels of dollar spot control. Multiple applications of compost (every 3 weeks) at a rate of 24.4 or 48.7 kg/100 m^2 reduced the severity of dollar spot to a level similar to 2-week applications of the fungicide chlorothalonil.

In clay soils, good quality compost will improve structure, reduce surface crusting and compaction, promote drainage and provide nutrients. In sandy soils, compost increases water and nutrient retention, supplies nutrients and increases microbial activity. These improvements promote faster turf establishment and improved turf density and colour, increase root growth and reduce the need for fertilizer and irrigation. Composts are made from many different materials, including household refuse (municipal solid waste), leaves and grass clippings (yard trimmings), sewage sludge (biosolids), animal manure, paper mill byproducts and food residuals, to name a few. Compost quality varies, depending on the source and how it is produced. Whether you are using a field-tested product or one that has never been used on turf, obtain a sample of the compost prior to use and examine it for undesirable objects and peculiar or offensive odours.

PESTICIDES

When it is necessary to use a pesticide, the first choice, ideally, should be a product that is least hazardous to people and the environment. They have one or more of the following characteristics:

- present the least short- and long-term health risk to humans
- have low impacts on non-target organisms (usually because of short residual effects). Broad-spectrum insecticides are toxic to beneficial insects as well as to pests. In one study conducted in Kentucky, certain insecticides applied

in June reduced the populations of spiders and rove beetles by as much as 60%, with effects lasting for at least 6 weeks. Different species are affected to various degrees by different insecticides. Most studies have suggested that predators will repopulate relatively small areas within 1–3 months after treatment.

- are most specific to the target species
- present the least risk to the environment during handling and disposal

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4. IPM for Weeds in Turf

IPM programs for weeds in turf are well developed in Ontario. Turfgrasses are used for lawns because they are tough, hardy and adaptable plants. Given good conditions, vigorous turf will outgrow most other kinds of plants, so preventing weed problems through good management should be the primary approach. As described in the section *2. Categorize the Sites*, on page 13, use a system for categorizing sites according to maintenance level to help plan your IPM program.

The IPM program for turf weeds described in this manual should be treated as a starting point only. Adapt it to suit your specific sites and revise it as new products and methods are developed.

PLANNING AND MANAGING TURF

When designing and planting turf areas, plan for long-term weed management by starting with the correct drainage, soil preparation and choice of turfgrass cultivars. Follow this with good turf management practices to ensure healthy, vigorous turf. The management methods that prevent weed problems and other pests (also called "cultural controls" in some references) include:

Select turfgrass cultivars suited to local conditions and intended use.

For example, choose wear-resistant perennial ryegrass for sports fields or shade-tolerant fescues for shaded areas in parks.

- Invest in the best quality seed available.

Use fertilizers that suit turfgrass nutritional requirements.

- For large or high-profile facilities, test soil and perform tissue analyses regularly to ensure that lime and fertilizer requirements are being met.
- Adjust application rates to avoid nutrient imbalances and to prevent leaching of soluble fertilizers beyond the root zone.

Follow good irrigation practices.

- Water deeply and infrequently. Avoid shallow watering, which promotes shallow rooting and the accumulation of thatch.
- Test for moisture requirements rather than relying on automatically timed intervals. Relate irrigation cycles to the local evapo-transpiration rates, soil type, drainage characteristics and species of turfgrass.
- Have manual overrides on automatic watering systems that are easy to adjust for unusually wet or dry conditions or use automatic rain delays to shut off irrigation during rainy periods.

Use correct mowing practices.

- Keep the mower height as high as possible for the turfgrass species and use of the site. This gives the grass plants more leaf area, so they grow more vigorously, with deeper roots, and are better able to compete with weeds. The dense turf also shades the soil, which prevents weed seeds from germinating. Most turfgrass species used in parks, home lawns and recreational fields can be mowed at a height of 5–7 cm. Mowing also removes the flowers of weeds, preventing them from setting seed. This also helps reduce the spread of weeds.
- Maintain sharp blades on mowers and mow as often as work schedules and budgets allow. For most turf, schedule mowing according to the growth rate of the turf, so that mowing removes no more than one-third of the plant height.
- Use mulching mowers and leave the grass cuttings on the turf to provide nutrients. This has been shown to replace up to 15% of the nitrogen fertilizer required and does not cause thatch to build up (but may not be advisable in cool, wet spring conditions when turf is growing rapidly).

Keep thatch to an optimum thickness.

A moderate layer of thatch (1–2 cm) is beneficial for most turf because it insulates roots from tempera-

ture extremes, reduces water loss and acts as a cushion to reduce compaction from wear.

- Remove excessive thatch by verticutting or raking.
- Where annual bluegrass is a problem, avoid dethatching operations in early fall or spring when weed seeds are germinating.

Manage turf to reduce soil compaction.

- Provide mechanical aeration as required, preferably with hollow-tine aerators instead of solid-tine equipment. Aerate once a year, more depending on the type of turf and use patterns.
- Avoid compaction from overuse. For example, rotate goal mouth areas and entrance points onto turf areas for people and equipment; alternate the direction of mowing; establish a sports field closure policy during poor weather and limit play on sensitive or stressed sports fields.

Promptly repair worn or damaged areas.

- Use overseeding, re-seeding or re-sodding to close openings in the turf and increase the density of turf plants. This prevents weeds from germinating and becoming established.

The key to managing turf weeds is preventing and correcting conditions that stress the turf plants. When weed populations exceed tolerance levels in turf, it is usually because the grass has been thinned out by poor conditions, such as drought, compaction, poor drainage, mowing too low, insect and disease damage, etc. Weeds adapted to those conditions will colonize any openings in the turf. Noting which species of weeds appear, and where, can help you diagnose the type of stress the turf is experiencing (see Table 4–1, *Conditions Favouring Weed Invasion in Lawns*, right).

TABLE 4–1.
Conditions Favouring Weed Invasion in Lawns

Weed	Conditions
Annual bluegrass *Poa annua*	Low fertility, compaction, mowing too short and excessive moisture
Algae (various)	Thin turf, wet conditions, high or low nitrogen depending on species
Black medick *Medicago lupulina*	Low fertility and drought
Buttercup *Ranunculus* spp.	Excessive moisture
Chickweed *Stellaria media*	Thin turf, excessive moisture and shade
Clover *Trifolium repens*	Low nitrogen, drought and compaction
Crabgrass *Digitaria* spp.	Thin turf, low fertility and compaction
Creeping bentgrass *Agrostis palustris*	High fertility, excessive watering and mowing too short
Moss (various)	Heavy shade, low fertility, low pH and compaction
Plantain *Plantago* sp.	Low fertility, mowing too short and drought
Prostrate knotweed *Polygonum ariculare*	Compaction, low fertility and drought
Rough bluegrass *Poa trivialis*	High fertility, excessive watering and shade

IDENTIFICATION

Collect leaves or whole plants and identify weeds by species if possible. Find out whether the plants are annuals or perennials, as well as other characteristics, such as whether they are grasses, broadleaf weeds or noxious weeds. This information will help you decide on the best management methods and when to use them. Weeds that cannot be positively identified should be carefully collected and pressed, if necessary, to preserve them for future diagnosis.

Identification resources include:

- reference books, plant guides (see *References*, on page 42)
- resources on the Internet
- staff at garden centres, community colleges, botanical gardens
- professional diagnostic services

Note: Specimens for identification can be sent to the Pest Diagnostic Clinic – Laboratory Services Division, University of Guelph, 95 Stone Rd. W., Guelph, Ontario N1H 8J7, Tel: (519) 767-6256, Fax: (519) 767-6240, or visit www.uoguelph.ca/pdc for identification and recommendations. There is a fee for this service.

MONITORING

Most monitoring programs for weeds in turf are based on visual inspections (rough estimations) and

on weed counts, which give a more accurate picture of the weed situation. For more information on the principles of sampling, see the section *Monitoring Methods*, on page 6.

Keep written records of all counts, as well as notes from visual inspections for future reference. Some turf managers also find it useful to keep photographs as a record.

Counting Methods

Transect Method Use a rope or string to stake out a 10-m transect (straight line) through an average section of turf. Walk along the line and record the plants you see in a 10 cm^2 area at 10 points along each side of the transect; check 5 or more transects per site. Averaging the scores from each type of site gives a percentage of weeds in the turf. Transect lines can be marked or knotted to show where to sample or you can pace along the length of the line and record the plants seen near your toe after each large stride. See Figure 4–1 and Figure 4–2, right.

Grid Method Make a wire or wood-frame grid, 1 metre x 0.5 m. Lay it down, randomly, on the turf and count how many weeds there are at each point where the strings transect. Count at least 10 grids per site. Average the scores to arrive at a percentage of weed cover. See Figure 4–3, right.

Centreline Method Walk the centre of sports fields from goalpost to goalpost and estimate the percentage of weed cover in a 10 cm^2 area at every second step.

Which Method

Which monitoring method you use depends on the site and the user. Once you choose a method, use the same one each time so that counts and averages can be compared from one year to the next.

When and How Often

The monitoring schedule depends on the category of the site, its history of weed problems, the local climate and the budget. Schedule monitoring to coincide with periods of active vegetative growth or flowering periods, when some weeds are easiest to see.

On Class-C (low-maintenance) sites, an occasional visual inspection may be the only monitoring required. On Class B sites, if a visual inspection

FIGURE 4–1. Transect method: shows a 10-m length of string placed at random in the turf.

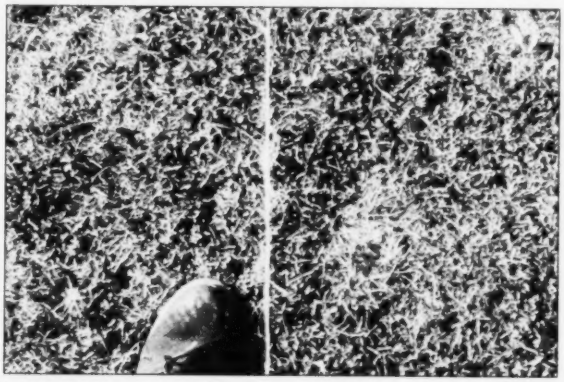

FIGURE 4–2. Transect method: Take 10 steps along each side of the 10-m string. Record whether a weed or grass appears at the point where the toe of your shoe lands. This can then be used to estimate percent weed cover.

Example: $\frac{20 \text{ weeds}}{100 \text{ steps}} = 20\%$ weed cover

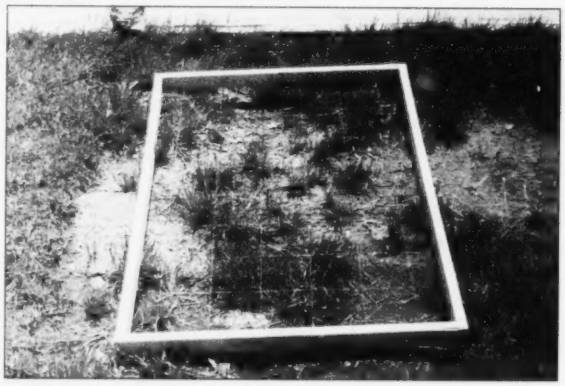

FIGURE 4–3. Grid method: The grid displayed has 20 transect points where the strings cross. Record the number of weeds at the 20 transects. Repeat 5 times.

Example: $\frac{15 \text{ weeds}}{100 \text{ transect points}} = 15\%$ weed cover

TABLE 4–2.
Examples of Action Levels/Thresholds for Weeds

Site Classification	Site Examples	Action Level/Threshold	Comments
Class A	Home lawns, golf and bowling greens, irrigated sports fields	From weed free to 5%–10% weed cover	Usually sprayed when 10%–15% weed cover is reached.
Class B	Sports fields, commercial lawns, golf course fairways, general park areas	From 20%–50% weed cover	Allowed as long as the function of the site is not compromised.
Class C	Passive park areas, including picnic areas, naturalized areas, golf course roughs	>50% weed cover	Controls may only be needed in the interest of public safety (i.e., to maintain sightlines, remove fire hazards or if noxious weeds are present).

shows cause for concern, count the weed population for a more accurate estimate. On high-profile (Class A) turf, do a weed count once or twice a year (early spring and late summer). Monitor and map for crabgrass in June. Treat infested areas with post-emergence crabgrass control in June or preventatively the following May. The IPM templates, starting on page 17, indicate when to monitor weeds based on a monthly timetable.

THRESHOLDS

On general-use turf, in parks and other public facilities, the need for treatment often depends on how many weeds the public will tolerate. On sports turf, safety considerations also influence treatment decisions because bare areas or large weedy patches can increase the slipping hazard. Playability is a key consideration in deciding when to treat on golf course and lawn bowling greens. On some home lawns, the threshold is no weeds at all. It is important to educate the homeowner to accept a few weeds in a lawn.

Examples of action levels/thresholds used by turf managers in Ontario are shown in Table 4–2, *Examples of Action Levels/Thresholds for Weeds*, above.

Develop action levels/thresholds using monitoring information for major sites or for each class of site. These should be quantitative (stated in terms of a number or measurement) for any sites where herbicide use is being considered. For future reference and to help in later evaluation, write down the criteria you use to make action decisions, such as percentage of weed cover, presence of noxious weeds species, risk of spread to adjacent turf, cost, etc.

Although there may not appear to be much difference between injury and action levels for turf weeds when herbicides are used, other types of treatments may have different action levels. For example, it may be justifiable to use a backpack infrared weeder to control dandelions in a public park to treat a lower weed population level than would be feasible using a herbicide. This is because using the pesticide would involve complying with regulatory requirements and public notification guidelines that do not apply to the infrared weeder, which could be used at any time.

Setting Thresholds for Weeds in a Lawn

When you ask people how many weeds they would tolerate in their front lawn, their first reaction is often "None!" But does "none" really equal "zero"? One study conducted in California found that people did not notice that there were weeds in a lawn until weed counts exceeded 5%–10%*.

Try this:

- Find some areas of turf that look "fine" to you, then count the weeds in 10 transects or grids (as described in the section *Counting Methods*, on page 39) and average the counts. Do the same for turf that you consider looks "marginal" and again for turf areas that look "poor."
- The whole exercise can be done fairly quickly. It should give you a better idea of acceptable and unacceptable weed counts, which can be used to set realistic injury and action levels.

* Olkowski, W., S. Daar, and H. Olkowski. 1991. *Common-Sense Pest Control.* The Taunton Press, Newtown, CT. p. 55.

CONTROLS

Knowing whether a weed is an annual or a perennial is important because it affects control decisions.

For example, control of annual weeds would focus on preventing seeds from spreading and on preventing dormant seeds in the soil from germinating (i.e., by minimizing disturbances to the soil). For perennial weeds, controls are usually used before the plants bloom, when nutrient reserves in the roots are at their lowest, and the plant is least able to grow new leaves.

Physical and Mechanical Controls

- Hand-pull small populations of weeds. There are several well-designed hand tools on the market that make weed pulling more efficient. This is easiest when the soil is moist but can be done any time of year and by anyone working on the site. Take care to disturb the soil as little as possible. As a weed is pulled out, sprinkle turfgrass seed in the opening to close the gap in the turf quickly and prevent weed seeds in the soil from germinating.
- Use a handheld flamer or infrared radiation applicator with a probe tip to control broadleaf weeds in turf (for heat treatment information, see the section *Heat Treatment for Non-Selective Vegetation Control*, on page 29).

Chemical Controls

The need to use herbicides on general-use turf usually shows that turf management methods need to be improved. However, if herbicide use is judged necessary, make sure the product selected is:

- effective and registered for the specific weed type
- applied as a spot treatment instead of a broadcast application wherever possible
- not phytotoxic to desirable turf species (e.g., some common turf herbicides kill bentgrasses)
- applied at the right time to have the greatest effect on target plants

Herbicides currently registered for use on turf in Ontario can be found in OMAF Publication 384, *Recommendations for Turfgrass Management*, or Publication 75, *Guide to Weed Control*. For precautions and guidelines for using pesticides in landscapes, see Chapter 7, *Safe Use Guidelines for Turf Pesticide Treatments*, on page 61.

EVALUATION

After any type of treatment, turf areas should be inspected for results at intervals appropriate to the type of treatment. For example, schedule an inspection 1–2 weeks after a herbicide treatment.

Use this information, along with other monitoring records, observations from field staff, feedback from clients, budget records, etc., to assess the effectiveness of the turf IPM program and find ways to improve it for next year. After several seasons of recording and evaluating, you should notice a long-term trend toward better turf quality and low weed populations.

If monitoring shows that weed populations continue to rise, re-evaluate your turf management practices. The goal should be to improve the health of the turf so that it is more competitive with weeds.

References

Olkowski, W., S. Daar, and H. Olkowski, 1991. *Common-Sense Pest Control*. The Taunton Press, Newtown, CT. (From: Bio-Integral Resource Center, PO Box 7414, Berkeley, CA 94707. Tel: (510) 524-2567, http://www.igc.org/birc/).

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Ontario Ministry of Agriculture and Food. 1993. *Weed Control in Lawns and Gardens*, Publication 529.

Quarles, W. 1999. *Non-Toxic Weed Control in the Lawn and Garden*. Common Sense Pest Control Quarterly. 15(3): 4–14. (From: Bio-Integral Resource Center, PO Box 7414, Berkeley, CA 94707. Tel: (510) 524-2567. http://www.igc.org/birc/).

5. IPM for Insects in Turf

Insects are generally more of a problem in turf in Ontario than in other areas of Canada. The most common insect problems are white grubs, which are the larvae of May or June beetles (*Phyllophaga* spp.), European chafers (*Rhizotrogus majalis*), Japanese beetles (*Popillia japonica*), hairy chinch bugs (*Blissus leucopterus hirtus*) and bluegrass billbug (*Sphenophorus parvulus*).

Given good management, turf usually outgrows moderate insect damage without needing treatment. It is not uncommon, however, for racoons, crows and other animals to dig up turf in search of grubs, causing much more damage than the insects themselves.

Less common insects that can still destroy large areas of turf are aphodius (*Aphodius granarius*), black turfgrass ataenius (*Ataenius spretulus*), sod webworm (*Crambus* sp. and *Pediasia* sp.) black cutworm (*Agriotis ipsilon*), annual bluegrass weevil (*Hyperodes maculicollis*), turfgrass scale (*Lecanopsis formicarum*) and, most recently, European cranefly (*Tipula paludosa*).

As described in the section *2. Categorize the Sites*, on page 13, use a system for categorizing sites according to maintenance level to help you plan your IPM program.

The IPM program for turf insects described in this chapter should be treated as a starting point. Adapt it to suit your specific sites and revise it as new products and methods are developed. Examples of IPM information about common turfgrass insects can be found in OMAF Publication 162, *Diseases and Insects of Turfgrass in Ontario*.

PLANNING AND MANAGING TURF

The elements of prevention (also called "cultural controls") for turf pests involve using optimum site design and management. When designing and planting turf areas, plan for long-term insect management by starting with the correct drainage, soil preparation and choice of turfgrass cultivars adapted to the conditions. Follow this with turf management practices that ensure healthy, vigorous turf (see Chapter 3, *Pest Management Recommendations*, on page 27, for additional management methods that contribute to healthy turf).

Insect-Resistant and Insect-Tolerant Turfgrasses

On sites where chewing insects, such as sod webworm, are a chronic problem, consider renovating and reseeding with grasses containing endophytic fungi. These fungi produce toxins that repel or kill leaf- and stem-feeding insects (they do not affect root-feeding species, such as leatherjackets or white grubs). Some cultivars of perennial ryegrass, fine fescues and tall fescues have high levels of endophytic fungi in the leaves. A study on mixed strands of endophytic perennial ryegrass and Kentucky bluegrass infested with hairy chinch bugs showed that the chinch bugs were able to avoid feeding on the endophytic perennial ryegrass and fed exclusively on the Kentucky bluegrass. This work suggests that monostands of endophyte-enhanced turfgrass cultivars are necessary to suppress hairy chinch bug feeding and damage. **Endophytic grasses must not be planted where livestock may graze.**

IDENTIFICATION

Correct identification of turf pests is essential, because monitoring and treatment methods must be tailored to a particular species. Once a problem species is identified, information about its life cycle can be used to pinpoint when treatments will have the greatest effect and what preventative measures will be most effective.

If you suspect an insect problem, search carefully among leaves and in thatch. Cut and fold back a section of sod or use a soil probe or cup cutter to remove a section of turf. Inspect the thatch layer, roots and soil for larvae, pupae and adult insects.

Collect insects and identify them from guides and other references or preserve them for later identification by an expert.

Identification resources include:

- reference books, plant guides (suggestions are listed at the end of the chapter)
- resources on the Internet
- staff at garden centres, community colleges, botanical gardens
- professional diagnostic services

Note: Lawn care companies, golf courses and municipalities can send samples to the Pest Diagnostic Clinic – Laboratory Services, University of Guelph, 95 Stone Rd. W., Guelph, Ontario N1H 8J7, Tel: (519) 767-6256, Fax: (519) 767-6240, or visit www.uoguelph.ca/pdc for more information. There is a fee for this service.

MONITORING

Estimate turf insect populations using visual inspections or one of the counting methods described below.

Visual Inspections

Walk over the turf areas, noting:

- damaged areas, which may show up as patches of wilting, yellowing or browning turf or bare areas
- signs that birds or other animals are pulling up the turf, indicating the possible presence of insects

Record information on a map or diagram for future reference.

For close visual inspections, use a hand lens and a soil probe or other tool to search deep in the thatch layer and root zone. Look for:

- life stages of insects, such as larvae or pupae, on the surface or among the roots in the soil
- symptoms of chewing or sucking on leaf blades, missing leaf blades
- silken webbing in the thatch layer
- insect frass (excrement), either soft green pellets or sawdust-like frass

Use Table 5–1, *Turfgrass Insect Injury Key*, on page 45, to help identify turf insect damage.

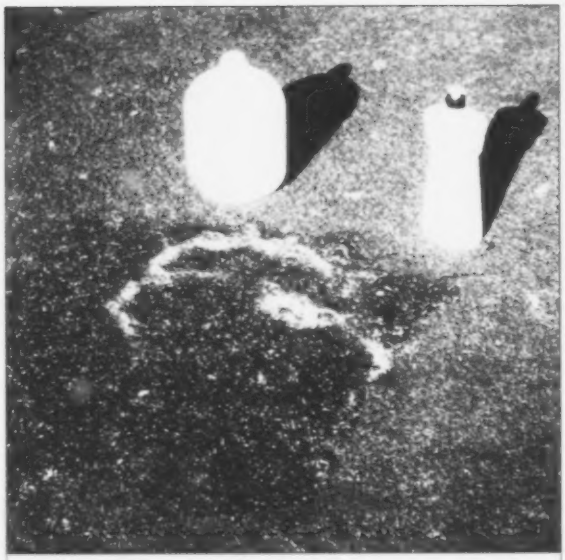

FIGURE 5–1.
Soap Drench for Monitoring Turf Insects
Mix 15–30 mL of liquid dish soap (not detergent) in 4L of water. Do not use more soap per gallon, because concentrated soap solutions can burn the grass leaves. Irritant solutions are most useful for active insects and larvae, such as leatherjackets and sod webworms.

Two ways to use the drench are:

- Mark an area of turf and use a watering can to soak the turf evenly with the soapy water. Watch closely for 10–15 min to spot larvae wiggling to the surface.
- Cut out the bottom of a large tin can (e.g., 2L), then push the bottomless can 5–10 cm deep into the turf. Pour soapy water into the can. As it soaks in, watch for larvae coming to the surface.

Counting Methods

- Fold back a measured section of sod or remove a plug of sod with a golf course cup cutter or other tool, then count and record the insects found among the roots. Replace the sod. This method is for grubs and weevils.
- Soak a measured area of turf with soapy water (see Figure 5–1, above). This irritates insects and drives them to the surface where they can be counted. This method is for caterpillars and adult black turfgrass ataenius.
- Cut out a measured section of sod and soak in a bucket filled with a saturated solution of salt water (add salt until no more will dissolve). Count the larvae that float to the top. This is a destructive sampling method that would not be appropriate for most landscape turf. This method is for leatherjackets.

TABLE 5–1.

Turfgrass Insect Injury Key

This key is composed of pairs of opposing statements (A and B) followed by either an insect name or a number. If there is a number at the end of the statement, refer to the pair of statements listed with that number and choose again from the pair of opposing statements. An insect name at the end of the statement indicates which insect causes the damage in the statement.

No.	Statement	Insect Name/Key Number
1A.	Turf not normally damaged and not generally discoloured, with no obvious feeding damage but with solid mounds.	2
1B.	Turf appears discoloured (browning, yellowing) or has obvious feeding damage present (e.g., missing leaves or stems, ragged or chewed leaves).	5
2A.	Mounds of soil present.	3
2B.	Mounds of soil absent.	5
3A.	Ants associated with mounds, 2.5–7.5 cm in diameter, resembling a small volcano with a hole in the middle.	ants
3B.	Mounds with no ants.	4
4A.	Mounds 2.5–7.5 cm in diameter, usually located within turf canopy and thatch that look like extruded castings.	earthworms
4B.	Large mounds of soil brought to the surface, large hole in the centre of the mound, associated with tunnels under turf.	moles
5A.	Turf spongy under foot, easily pulled up.	6
5B.	Soil under turf firm.	7
6A.	Turf spongy under foot that, when pulled, separates at the **soil/thatch** interface.	scarab grubs
6B.	Turf spongy under foot that, when pulled, separates at the **turf/thatch** interface, with soft pellet-like frass present.	sod webworm, cranberry girdler
7A.	Turf sparse, no chewed leaf blades or small chewed holes.	8
7B.	Turf sparse, chewed leaf blades.	10
8A.	Individual grass plants or small groups of grass plants turn yellow. When a "tug test" (sharp pulling of turf blades) is performed, the blades pull out easily. Stems and thatch have sawdust frass evident.	annual bluegrass weevil or bluegrass billbug
8B.	When "tug test" performed, turf does not pull out easily, no frass evident.	9
9A.	Dead patches yellow to brown and sunken in summer. Inspection of base of plants reveals red, brown or black-and-white insects from 1–3 mm long.	hairy chinch bugs
9B.	Dead patches yellow in spring. Inspection of base of plants reveals small pink, waxy or cottony-coated insects.	turfgrass scale
10A.	Leaf margins chewed on long grass or cropped down in spots on short grass (e.g., golf course putting greens) and soft, pellet-like frass present.	cutworms
10B.	Turf sparse, leaves removed, inspection at top of soil or in thatch reveals grey/brown maggots 1–2.5 cm long.	European cranefly larvae (leatherjackets)

Modified from Shetlar, D.J. 1995. *Key to Turfgrass Pests.* In R.L. Brandenburg and M.G. Villani (eds). *Handbook of Turfgrass Insect Pests.* Entomological Society of America, Lanham, MD.

Hairy Chinch Bug Monitoring Techniques

A modification of the coffee can technique for monitoring for hairy chinch bugs is currently being used in Ontario. A cup changer–sized plug (10 cm) of turf taken from the edge of a damaged area is submerged in a bucket of water. If chinch bugs are present, after several minutes they will float to the top of the water. The turf plug can be replaced into the lawn.

For future reference, keep written records of counts as well as notes and maps of damage from visual inspections. Some turf managers also find it useful to keep photographs as a record.

> References on turf pest management from the U.S. and Canada use a variety of measurements, in both imperial and metric measuring systems. See Appendix D, *Useful Equivalents for Converting Sampling Areas*, on page 82.

Which Method

The choice of monitoring method depends on the site, the user and the suspected pest problem. For example, soap drenches work well to drive out active larvae but not white grubs. Once you choose a method, use the same method each time so that counts and averages can be compared from one year to the next.

When and How Often

The monitoring schedule depends on the category of the site and the life cycle of the problem insect. Intensive monitoring may be necessary for a few weeks in the spring for several species but may not be necessary at other times of the year. The IPM templates, starting on page 17, indicate which insects to monitor monthly.

THRESHOLDS

On general-use turf, in parks and other public facilities, thresholds depend on what the users will tolerate and how vigorously the turf is growing. On sports turf, safety considerations also influence treatment decisions, because bare patches can increase the slipping hazard. Thresholds also depend on the category of site. For example:

Class A sites There is low tolerance for infestations of insects because of the potential for deterioration of playing surfaces, safety and aesthetic values.

Class B sites Higher insect counts are tolerable unless their presence is attracting secondary pests, such as crows, starlings, skunks and racoons to dig up the turf.

Class C sites Generally, insects are not a concern.

CONTROLS

Avoiding insecticide use in favour of improved cultural methods has the advantage of preserving the naturally occurring beneficial insects and mites that control pests. For a summary of cultural controls, see the section *Management*, on page 2.

Biological Controls

Insect parasitic nematodes are the only type of biological control produced commercially at this time for turf pests. These are microscopic worms that move through the soil to attack insects (for more detailed information, see the section *Insect Parasitic Nematodes*, on page 32). Depending on the species of nematode available (it varies from year to year), they may be used for leatherjackets, white grubs, black turfgrass ataenius, cutworms and other turf pests.

Nematodes are sold in a dormant stage, which is mixed in water and applied to the soil. They can also be applied through irrigation systems. They must be applied with sufficient water (at least 1.5 cm) to carry the nematodes down to the root zone where the pests are feeding. Irrigating both before and after applying nematodes has given better results than irrigation only after application.

Note: Nematodes are not active in cold soil conditions, and most species are only effective when soil temperatures are above 12°C. Always consult suppliers for advice on which species and methods of application to use.

Chemical Controls

Root-feeding, stem-feeding and foliage-feeding insects are all turfgrass pests, most often controlled by insecticides. Understanding their life cycles plays a major role in controlling their potential damage and spread.

FIGURE 5–2. European cranefly adult.

FIGURE 5–3. Cranefly larvae (leatherjacket).

Where possible, avoid broadcast or blanket applications of insecticides. These have been shown to reduce the natural populations of the beneficial insects and mites that eat the eggs and larvae of turf pests. Where possible, use spot treatments with selective insecticides. This reduces treatment costs and protects beneficial species.

If you must use an insecticide treatment, make sure the product selected is:

- effective and registered for the specific insect
- applied as a spot treatment instead of broadcast application wherever possible
- applied at the right time to have the greatest effect on target species. For example, timing pesticide applications for larval control is critical and must be determined by monitoring, since chemical treatments are more effective when larvae are actively feeding in the root zone.

Insecticides that are currently registered for use on turf in Ontario can be found in OMAF Publication 384, *Recommendations for Turfgrass Management*. For more precautions and guidelines for using pesticides in landscapes, see Chapter 7, *Safe Use Guidelines for Turf Pesticide Treatments*, on page 61.

EVALUATION

At the appropriate interval after any type of treatment, use visual inspections or counting methods to assess the effect. Check problem areas the following season at the right time in the life cycle of the insects to look for damage or count populations.

Use this information, along with other monitoring records, observations from field staff, feedback from clients, budget records, etc., to assess the effectiveness of the turf IPM program and find ways to improve it for next year.

IPM EXAMPLES

Following are descriptions of four common turf pests with notes on monitoring, action decisions and treatments that could be incorporated into an IPM program. In any IPM program, correct identification of the pests before taking action is critical, as is the evaluation step to determine how to improve the program in the future.

European Cranefly
(*Tipula paludosa*)

European cranefly adults resemble large mosquitoes (see Figure 5–2, left). They range in length from 1.5–2.5 cm and have a greyish-brown body. The adult cranefly has two narrow wings and very long brown legs. Unlike mosquitoes, however, they do not sting or bite and are relatively weak flyers. Eggs are laid in the upper 2–4 cm of the soil and are black and oval in shape and roughly 0.1 cm long. The larvae of the European cranefly are known as leatherjackets because of their thick skin. They are light grey or greenish-brown with irregular black specks. Leatherjackets are cylindrical but taper slightly at both ends and are typically 3–4 cm at maturity (see Figure 5–3, above). The pupa is formed inside the last instar cuticle and is called a puparium. The pupae are brown and spiny and are 3.3 cm in length.

There is one generation of *T. paludosa* in Ontario. Fourth-instar larvae have been found feeding on the

FIGURE 5–4. Typical leatherjacket damage on a home lawn.

top of the soil in early May when sampling first begins. They grow rapidly at this stage and typically reach their full length (3–4 cm) by mid-June, which is when the majority of the damage is noticeable. By the second week in June, the larvae have stopped feeding and have moved down 3–5 cm deep in the soil where they remain in a non-feeding stage throughout the summer until they pupate in late August. At this time, the pupae wiggle to the surface and adults emerge, usually after sunset, and are at sexual maturity. They mate immediately and the females lay between 200–300 eggs within 24 hr of emerging. The males typically survive for 7 days, while females live for only 4–5 days. Adult flights lasted for 2 weeks from Sept. 21 to Oct. 4, 1999, and Sept. 6 to Sept. 27, 2000. The eggs are laid on the soil surface or at depths of less than 1 cm. They require immediate moisture to survive and hatch 11–15 days later. Eggs of *T. paludosa* have been found during the last week in September. Upon hatching, the larvae feed immediately throughout the fall and warm periods of the winter in the upper 3 cm of the soil. The first-instar larvae have been found in the first week in October and second-instar larvae found weekly from mid-October until the middle of November. Leatherjackets usually complete the first two instars within two months of hatching and winter as third instars when their metabolism slows down.

The leatherjackets feed primarily on turf on home lawns, golf courses and sometimes pasture grasses. They feed during the day at or below the surface of the turf on root hairs, roots and crowns. On damp warm nights, they migrate to the surface of the turf and eat stems and grass blades. Damage to turf in Ontario occurs in May (see Figure 5–4, above). The peak damage was in early May in 1998 and in late May in 1999. Damage can occur on golf greens from birds pecking out the leatherjackets from the greens in May.

A survey was conducted in 1998 and an informal survey conducted in 1999 and 2000. These revealed that the main areas of infestation were Ancaster, Niagara Falls, Hamilton mountain, Scarborough, Uxbridge, Oshawa/Whitby, Brampton, Markham, Kitchener/Waterloo and Guelph. This pest has spread very rapidly through many areas of south-western, central and eastern Ontario. Even though this insect thrives in mild winters, cool summers and areas with high annual rainfall, it has become well established in many areas of Ontario.

Monitoring

There are three recommended methods of monitoring for leatherjackets.

- In early spring, drench 1-m^2 areas of sod that show signs of damage with soapy water solution (see Figure 5–1, on page 44). Count the leatherjackets that wiggle to the surface.
- In spring or fall, pull back measured sections of sod and pick through the soil and roots to count larvae and pupae.
- Soak sections of sod in a saturated solution of salt water. Count the larvae that float to the top.

For all methods, take 5–10 samples per site and average the counts.

Thresholds

(These action thresholds are based on data from British Columbia and have not been verified for Ontario conditions.) Examples of thresholds used by turf managers for leatherjackets in British Columbia are:

Class A sites: 2.0–2.5 larvae/0.1 m^2 in spring
Class B sites: 5–10 larvae/0.1 m^2 in spring
Class C sites: over 10 larvae/0.1 m^2 in spring or 30 larvae/0.1 m^2 in fall (the higher level in the fall is acceptable because many larvae die over winter)

Controls

Control measures are directed toward the larval (leatherjacket) stage. Treatments must be made when they are actively feeding in the roots in October or from April to early June. Treatments applied at other times of year are not effective.

Biological Control Biological control of leatherjackets has been effective in British Columbia. They are currently being tested in Ontario for control. Apply insect parasitic nematodes (*Steinernema feltiae*) in the fall or as soon as the soil warms in the spring. Nematode products vary, so be sure to follow label recommendations for release rates and methods.

Chemical Control Although not usually recommended for general-use turf because of the long-term harm to beneficial insects and mites that control craneflies (and other pests), carbaryl can be used on golf courses for leatherjacket control where high larval counts justify treatment in October or from April to early June. Fall treatments may be preferred so that the leatherjackets are controlled before damage occurs, which is usually in early May. There are currently no insecticides registered for use on leatherjackets on home lawns in Ontario. Check OMAF Publication 384, *Turfgrass Management Recommendations*, for the most current pesticide recommendations for leatherjacket control.

White Grubs — May or June Beetles (*Phyllophaga* spp.)

White grubs are the larvae of May or June beetles. The larvae are large (up to 3 cm long), C-shaped grubs with reddish-brown heads. They feed on the roots of grasses. Common species take 3 years to develop, moving deeper in the soil for the winter and rising to the root zone again in the spring. Full-grown grubs burrow 20–25 cm below the surface during July to pupate. The adults stay there to spend the winter and emerge from the soil in the spring. For more information on white grub life cycles, see OMAF Publication 162, *Insects and Disease of Turfgrass in Ontario*, Table 2. *Turfgrass Insect Activity Time Profile (Southern Ontario)*, page 19.

Monitoring

Lift sections of damaged sod, up to 10 cm deep, or use a cup changer, and search through the roots. Count and record the number of grubs, then replace the sod. Count larvae in May or early June, before they burrow deeply to pupate.

Thresholds

Examples of injury levels:

- In healthy, irrigated turf, average counts of up to 15 larvae/0.1 m^2, in spring, may be acceptable.
- In non-irrigated stressed turf, average counts of 5–10 larvae/0.1 m^2 may require treatment.

Controls

Biological Control Some species of insect parasitic nematodes (e.g., *Steinernema carposapsae, Heterorhabditis bacteriophora*) have been shown in some studies to be effective in controlling white grubs. Apply nematodes after soil temperatures have warmed and use sufficient water to flush nematodes down into the root zone of the turf. Always check with suppliers for availability of species and methods of applications. For nematode treatment to work, read the label very carefully and make sure that all the environmental conditions necessary are met.

Chemical Control Spot treatments of pesticides where sampling had identified high populations may be sufficient, because white grubs usually occur in patches. Check OMAF Publication 384, *Turfgrass Management Recommendations*, for the most current pesticide recommendations for white grubs.

Black Turfgrass Ataenius (*Ataenius spretulus*)

The larvae of this small, 5 mm long beetle are white grubs that feed on the roots of grasses. Damage appears as irregular dead patches in turf and can look like damage from some turf diseases. The adult beetles overwinter in the soil and emerge in April and May. They are mainly a pest of golf courses in Ontario.

Monitoring

Visual Inspections

- Look for adult beetles around outdoor lights, which strongly attract them; check irrigation valve boxes, where beetles congregate in moist conditions.
- Inspect the top layer of turf, particularly following heavy irrigation when they are more visible.
- Inspect thatch in the fall, along the perimeters of greens, which is an area preferred by the beetles.

Counting Methods

- Pour 4 L of water mixed with 20 mL of dishwashing soap onto a 0.1 m^2 area of turf (see Figure 5–1, *Soap Drench for Monitoring Turf Insects*, on page 44) to drive adults to the surface for counting.

- Use a golf course cup cutter or other tool to remove sod samples. Look for larvae at the point where the soil and thatch layer meet.

Counting the numbers of larvae in the soil can be done roughly 2 weeks after the flights of adult beetles are first observed or adult beetles are first found in visual inspections.

Thresholds

Thresholds used in Ontario are 30–40 larvae/0.1 m^2 (300–400 larvae/m^2), especially if turf is under stress.

Experience has shown that heavy damage occurs when there are 250–300 larvae/0.1 m^2 (2,500–3,000 larvae/m^2).

Controls

To prevent spreading beetles to other areas, wash mowers and clean out mower baskets to remove adult beetles (don't forget to kill the collected beetles).

Appy pesticides several weeks after noticing large adult flights and verifying the presence of larvae by monitoring.

Sod Webworms or Cranberry Girdler (*Crambus* spp. and *Chrysoteuchia topiaria*)

Sod webworms are small, greenish caterpillars (6–19 mm long), covered with short bristles. They are the larvae of small, light brown moths, which lay eggs in the turf. The larvae live in short, silk-lined tunnels at the base of grass plants, where they feed at night, chewing in the thatch, separating the roots from the shoots. Damage appears as small, dollar-sized circular patches of thin turf. The last generation of larvae spends the winter in these tunnels and starts feeding again in the spring.

Monitoring

- Inspect thatch closely for green pellets of caterpillar excrement, for signs of webbing and for larvae in silken tubes.
- Drench a measured area of turf with soapy water (4 L of water mixed with 20 mL of dishwashing soap) onto a 0.1-m^2 area to drive larvae out of their tunnels and make them easier to see (see Figure 5–1, *Soap Drench for Monitoring Turf Insects*, on page 44).
- Count the number of larvae in measured areas of sod in several sample sites.

Thresholds

- Healthy turf may support up to 2–3 larvae/0.1 m^2 (20–30 larvae/m^2).
- Stressed turf may be damaged by as few as 1 larva/0.1 m^2.

Controls

Reduce thatch if it is over 2 cm deep, as webworms prefer thick layers of thatch.

Where sod webworms are a chronic problem, reseeding with endophytic grasses may be an option for long-term control.

Biological Control Some species of insect parasitic nematodes (e.g., *Steinernema carpocapsae* and *Heterorhabditis megidis*) have been found to control larval stages of the cranberry girdler.

Chemical Control Carbaryl is registered for sod webworms.

For more information on description, biology, damage, monitoring and control of turf insects, consult OMAF Publication 162, *Diseases and Insects of Turfgrass in Ontario*, and Publication 384, *Turfgrass Management Recommendations*.

For further information on the description and life cycle of insects that affect turf in Ontario along with the damage that they cause and suggested control methods, please refer to *Diseases and Insects of Turfgrasses in Ontario*, OMAF Publication 162 (1996).

Black Cutworm Management

Recent research (Shetlar, Potter and Williamson) has revealed some interesting new information about the biology of black cutworm that is important when considering a control strategy. This research shows that female cutworms lay their eggs on the tips of the turf leaf blades. On greens and tees that are mowed several times per week, the eggs are removed and discarded with the clippings, usually in out-of-play areas surrounding the greens. It appears that the young cutworm larvae develop in these sites and move back onto the greens and tees once they have reached the fifth and sixth instars. Research suggests that daily mowing removes most of the black cutworm eggs laid on putting greens.

However, since the eggs may survive in grass clippings, it is important to dispose of clippings well away from greens. If the clippings are deposited in the area surrounding the greens and tees, insecticide treatment should extend to the surrounding areas for a 10-m strip to control any large cutworm larvae living in the out-of-play areas that have the potential to re-infest the greens and tees.

Organic Fertilizers and Black Turfgrass Ataenius (BTA)

These pests belong to a group of small beetles that in natural habitats feed mostly in animal dung or decomposing organic matter and, as a result, may be interested in odours emanating from organic fertilizers. Studies have in fact shown that certain types of fertilizers may attract BTA adults, resulting in higher grub populations in turf. Organic fertilizers are often preferred because they do not burn, are slow release and resist leaching. Organics contain sulphur, iron and trace elements that may enhance plant metabolism and resistance. Although results may suggest that some organic fertilizers may be a risk factor for BTA, the risk probably does not outweigh the benefits of these fertilizers. BTA is a sporadic problem, and many golf courses never see damaging infestations. Nevertheless, if you use organic fertilizers, monitor for BTA and consider preventive management if the beetles and grubs are abundant.

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6. IPM for Diseases in Turf

Turf management, especially with respect to diagnosing and managing diseases on highly managed turf, is a complex, technical field. This chapter is intended to provide the general framework of an IPM program for turf diseases. For more information, consult the references listed at the end of the chapter. In particular, anyone managing large areas of turf should obtain a copy of OMAF Publication 162, *Diseases and Insects of Turf in Ontario.* As described in the section *2. Categorize the Sites,* on page 13, use a system for categorizing sites according to maintenance level to help plan an IPM program.

The IPM program for turf diseases described in this chapter should be treated as a starting point only.

PLANNING AND MANAGING TURF

Prevention is the main strategy for managing turf diseases. Before any disease can occur, three elements must be present: a susceptible plant, the disease agent (called a pathogen) and favourable environmental conditions for the development and spread of the pathogen. If any part of this "disease triangle" is missing, disease does not develop. Prevention of turf diseases is based on removing one or more of these elements.

Prevention for all turf pests involves using optimum site design and management. When designing and planting turf areas, plan for long-term disease management by starting with the correct drainage, soil preparation and choice of turfgrass cultivars adapted to the conditions. Follow this with turf management practices that ensure healthy, vigorous turf (see Chapter 3, *Pest Management Recommendations,* on page 27, for more management methods that contribute to healthy turf).

Conditions that predispose turf to most fungal infections include overly lush growth (i.e., from overwatering or over-fertilizing with quick-release nitrogen) and prolonged periods of leaf wetness (i.e., through natural weather conditions or poor irrigation practices). Other contributing factors are mowing too short, compacted or poorly drained soils, temperature stress (too hot or cold for the type of grasses), drought or waterlogged conditions (from under- or over-watering) and nutrient deficiencies and imbalances.

Cultural Practices

Specific cultural practices (also called "cultural controls") help prevent turf diseases.

Reduce Periods of Leaf Wetness

- Reduce the time dew spends on leaves. "Dew" on turf includes guttation water, which leaks out of cut grass blades, carrying with it sugars and other nutrients. This gives fungi a food supply and also allows the pathogens to move on a film of water to nearby plants. Sweep or drag light hoses or poles across the turf to disperse dew early in the day or irrigate for a short period early in the morning (i.e., for 2–3 minutes, 2 hours after sunrise) to dilute and wash off the nutrient-rich dew.
- Time irrigation for early morning, rather than evening, to allow leaves time to dry thoroughly during the day. Use manual overrides on automatic watering systems so they can be readily adjusted to avoid overwatering in wet weather or use automatic rain delays to shut off irrigation in rainy weather.
- Prune nearby trees and shrubs to reduce shade and increase air movement across the turf, which will speed drying of the leaf blades.

Plant Disease-Resistant Turfgrasses

As environmental stewards, golf course superintendents are always in search of ways to reduce fungicide use on putting greens. Preventative fungicide applications are commonly used from June through September in Ontario to suppress dollar spot and brown patch and maintain a high-quality putting

surface. To reduce fungicide use, superintendents may be interested in planting newer, more disease-resistant cultivars.

Research has indicated differences among cultivars in susceptibility to dollar spot and brown patch. For example, Penncross and Penn A-1 exhibit relatively good resistance to dollar spot, whereas Crenshaw and Providence do not. The cultivar L-93 had relatively good resistance to brown patch, but Penn A-4 was more susceptible.

A curative application strategy is often an important component of an integrated pest management program. Fungicides are applied when a predetermined threshold of disease severity occurs. This ensures that applications are made only when necessary and may result in reduced fungicide and labour inputs. The high susceptibility of creeping bentgrass to dollar spot and brown patch has traditionally prevented the use of curative strategies. The advent of more disease-resistant creeping bentgrass cultivars may allow for curative strategies to be successfully employed without noticeable loss in bentgrass quality.

Velvet bentgrasses also generally have high resistance to most turfgrass diseases. SR 7200 has been shown to have excellent resistance to dollar spot and brown patch. It has shown good resistance to fusarium patch. Most turf is highly resistant to *Pythium* sp. diseases but susceptible at the seedling stage. Late-season seeding or using seed treated with Apron® (metalaxyl) will generally resist these seedling *Pythium* sp. diseases. See the section *Turfgrass Species*, on page 27, for more information.

Use Correct Mowing Practices

Mow at the correct height for the turfgrass species. Keep all mower blades sharp to reduce bruising and tearing of leaves, which provides a pathway for fungal attack.

- Avoid mowing turf when blades are wet, as this increases the probability of spreading diseases.
- Clean clippings from the underside of mowers between jobs to reduce spread of disease.
- Allow turf to grow longer before the dry summer season or when a disease is observed. This depends on the disease, as some leaf diseases, such as red thread, can be managed by mowing, which removes the infection.

Manage Traffic on Turf

Schedule maintenance procedures to avoid working in weather and turf conditions that favour the spread of diseases. Manage use of playing fields and greens to reduce damage and excessive wear, especially during wet, cool weather.

Remove Snow and Ice

To reduce diseases caused by snow moulds, turf can be protected with covers or straw mulches. Some managers apply peat, soot, well-aged manure or a dark-coloured fertilizer (e.g., Milorganite®) to speed the melting of snow and ice. Ice can also be broken up with some types of aeration equipment.

IDENTIFICATION

Correct identification of diseases is essential because management methods must be tailored to fit the pathogen. Diseases are often difficult to diagnose as different diseases have similar symptoms. Also, symptoms may be mistaken for injury caused by poor growing conditions or physical damage. Diseases with similar symptoms may need to be positively identified by a plant pathologist.

To aid in diagnosing the problem, knowledge of the weather conditions in the preceding weeks is usually critical. Use Table 6–1, *Key to Turfgrass Diseases of Ontario*, on page 55, to help diagnose turfgrass diseases based on recent weather and readily visible symptoms.

Other important factors are:

- when and what kind of fertilizer or soil amendments have been used
- irrigation amounts and timing
- whether pesticides (including fungicides) have been used, what products and when
- wear and use patterns
- physical characteristics of the site, such as low lying areas, north side of slope, etc.

Accurate diagnosis usually requires careful collection of affected turf roots, stems, leaves and crowns and the use of a microscope or hand lens. The sample must be taken from the area where the pathogen is still active. This is important because fungi found in dead turf may be decomposers and not the pathogen that killed the plant. The area of active infection is usually in the zone of turf between healthy and diseased

TABLE 6–1. Key to Turfgrass Diseases of Ontario
(Hsiang, 2001)

Symptom	Disease
I. At Snowmelt	
A. Non-circular patterns or streaks of bleached or dead grass across large areas, particularly if snow cover was absent during very cold weather	abiotic winter injury
B. Patches of dead grass up to 30 cm across after snowmelt	
1. Little or no snow cover with abundant rain; irregularly shaped patches less than 10 cm across; wet grass sometimes covered with pink fuzzy growth; reddish-bronze at patch margins.	fusarium patch
2. At least 1 month of snow cover; circular brown or bleached patches up to 30 cm; wet grass sometimes covered with light pink fuzzy growth; no sclerotia present.	pink snow mould
3. More than 2 months of constant snow cover; circular patches up to 30 cm; wet grass covered with white to grey-white growth at patch margins; small sclerotia on top of fuzzy white growth or in dead plant tissues.	grey snow mould
a. Reddish-brown to dark brown sclerotia up to 5 mm across; more than 2 months of snow cover.	*Typhula incarnata*
b. Small, round black sclerotia up to 2 mm across; more than 3 months of snow cover.	*Typhula ishikariensis*
II. Spring or Fall	
A. Irregular patterns in grass	
1. Powdery growth on leaf surfaces; distinct leaf spots not usually evident.	
a. White powdery fuzzy growth on leaf surface; in shaded areas, grass thins out.	powdery mildew
b. Black streaks in leaves, which split into ribbons and curl; irregular patches or thinning out of grass.	leaf smuts
c. Pink or reddish growth on leaves and sheaths; red, threadlike growths extend beyond the leaf tips; low nitrogen grass.	red thread/pink patch
2. Seedling turf is thin or bare in spots; seedlings wilt and collapse; soil very wet.	damping-off
3. Leaf lesions of oval tan spots with dark borders.	leaf spot
4. Irregular spots on leaves; tip dieback; dark specks present in older leaves.	ascochyta leaf blight
5. Diffuse patches or blighting during wet weather.	
a. microscopic hairlike structures on dead tissues	anthracnose basal rot
b. thick-walled oospores on infected roots	pythium root rot
6. Blue, grey, creamy yellow or black covering on leaves that are easily wiped off; after prolonged rainfall.	slime moulds
B. Circular patches or rings of dead grass	
1. Circular yellow tufts of grass usually less than 10 cm across; following prolonged wet period.	yellow tuft
2. Irregularly shaped patches less than 10 cm across; common after prolonged wet period; wet grass sometimes covered with pink fuzzy growth; reddish-bronze at patch margins.	fusarium patch
3. Yellow rings with green centres; patches may be larger than 50 cm.	yellow patch
4. Rings initially yellow, then reddish-brown and finally straw-coloured; creeping bentgrass most susceptible; centre often invaded by weeds or other grasses; common in high soil pH and newly built sand greens.	take-all patch
5. Straw-coloured dead rings in well-watered Kentucky bluegrass, up to 90 cm across.	necrotic ring spot
6. Rings or arcs up to several metres across; often with outer ring of dark green grass or mushrooms.	fairy ring
III. Summer	
A. Diffuse blighting or irregular patches.	
1. Leaf spotting in a wet spring followed by a hot, dry period leads to irregular patches of dead grass with dark lesions on crowns or rhizomes; grass pulls out easily and resembles insect damage.	melting out
2. Seedling turf is thin or bare in spots; seedlings wilt and collapse; soil very wet.	damping-off
3. Bright orange or reddish-brown spots on leaves less than 3 mm across; during dry periods late in summer.	rusts

TABLE 6–1. Key to Turfgrass Diseases of Ontario
(Hsiang, 2001)

Symptom	Disease
4. Diffuse blighting or patches with bronze colour in creeping bentgrass; microscopic, hairlike structures on dead tissues.	anthracnose basal rot
5. Diffuse blighting or patches in low-lying or poorly drained areas; dead and dying roots with thick-walled oospores in infected tissues.	pythium root rot
6. Irregular patches of dead grass; very thick thatch; hydrophobic soils.	localized dry spot
B. Large areas wilt and turn brown, often during very hot, very humid weather	
1. Grass turns yellow, then reddish-brown; small, black, hairy structures on dead tissues; most common on annual bluegrass.	anthracnose foliar blight
2. Grass rapidly turns brown and dies in patches (shorter grass) or diffuse blighting (taller grass), often following drainage or traffic patterns; cottony-white fuzzy growth around patches when wet.	pythium blight
C. Round patterns in grass	
1. Patches 2–15 cm across during humid weather.	
a. Dead grass blades matted, slimy-looking and straw-coloured; dead grass may occur in streaks following drainage, traffic or equipment-use patterns; white, cottony growth over wet leaves.	pythium blight
b. Straw-coloured patches up to 5 cm across; cobweb-like growths may be found with dew; leaf blades have straw-coloured lesions with dark borders, often in an hourglass shape.	dollar spot
2. Circular patches up to 50 cm or even 1 m across.	
a. Straw-coloured; centres often remain green; pronounced during drought.	
i. mostly on Kentucky bluegrass or fine fescues	necrotic ring spot
ii. mostly on creeping bentgrass	take-all patch
iii. mostly on annual bluegrass	summer patch
b. Light brown patches; following wet periods; purple brown ring at patch margin during heavy dew.	brown patch
3. Rings or arcs up to several metres across. These fairy rings may have one, two or all three symptoms below.	
a. Dead rings with green centres	fairy ring (killing ring)
b. Stimulated green rings or arcs	fairy ring (stimulated ring)
c. Ring or arcs of mushrooms sprouting after wet weather	fairy ring (mushroom ring)

plants, such as at the edges of patches, rings or spots. Carefully separate individual plants and tease out the roots to try to determine which part of the plant is affected (i.e., roots, crown, leaves). Rinse roots in water to check whether they are white and healthy or yellow, brown or rotted. Some leaf diseases may be secondary problems on turf that has a root disease or is growing poorly due to other factors.

Check soil in the root zone for a "black layer" (caused by lack of oxygen due to compaction and poor drainage) or a "dry layer" (water does not penetrate to the root zone).

Compare with photographs in identification guides using:

- signs of the disease, such as fruiting bodies, spores, mycelium
- symptoms of disease, such as wilting, colour of leaf, leaf spots, shape, colour and size of affected patches

Identification resources include:

- reference books, plant guides (suggestions are listed at the end of the chapter)
- resources on the Internet
- professional diagnostic services

Note: Professional services and companies may send samples to the Pest Diagnostic Clinic – Labora-

tory Services, University of Guelph, 95 Stone Rd. W., Guelph, Ontario N1H 8J7, Tel: (519) 767-6256 Fax: (519) 767-6240, or visit www.uoguelph.ca/pdc. There is a charge for this service.

Refer to Appendix B of OMAF Publication 162, *Diseases and Insects of Turfgrass in Ontario*, for specific instructions on how to collect and package turf samples to ensure that active disease organisms are present. When sending samples to a lab, provide as much background information as possible about weather conditions, turfgrass species, cultivars, any pesticide use, fertilizing, irrigation and other management practices.

MONITORING

Monitoring for turf diseases starts with keeping records of weather conditions, such as temperature, rainfall, relative humidity and light levels. Inspections for diseases should be conducted during the seasons and the periods of weather that favour disease development. Train all staff involved in managing turf to know what to look for and how to recognize early symptoms of the turfgrass diseases most likely to appear on the site. Monitoring methods for turf diseases include:

Visual Inspections

- Walk over the turf areas, noting damaged areas and symptoms of damage, such as shape, colour, size of patches and where the damage is in relation to soil or other conditions (shade, waterlogged or dry areas, etc.). Record information on a map for future reference.
- Use a hand lens for close visual inspection and a soil probe or knife to search deep in the thatch layer and root zone. Inspect turf leaf blades under a hand lens or magnifying glass to detect early signs of disease. Check roots as described in the section *Identification*, on page 54.

Counting Methods

- Measure the width of active disease rings to use as an indicator of how fast the disease is spreading. It can be useful to mark the boundary of diseased areas to show changes over time.
- Count the number of disease patches in transects or grids using the same methods described for weed monitoring in the section *Monitoring*, on page 38.

Be sure to keep written records of all counts, as well as notes, photographs and maps of damage found during visual inspections, for future reference.

When and How Often

The monitoring schedule depends on the category of the site, on how susceptible the turfgrass is to diseases and on weather conditions, which are critical in influencing the growth of fungi. Monitoring carefully and often during expected infection periods makes it possible to catch disease infections early. For example, on highly managed turf (i.e., Class A sites), monitoring several times a week, or even daily, may be necessary during damp weather but would be done less often at other times of the year. Familiarize yourself with past disease problems on specific sites to help you plan when and what to look for in the current year.

Class C turf may not require any monitoring, as disease is seldom a problem on this type of site. Table 2-2, *IPM Golf Course Template*, on page 19, indicates which disease to monitor on a monthly basis.

THRESHOLDS

How much injury from fungal diseases is tolerable depends a great deal on the particular disease and the susceptibility of the turfgrass. It also depends on whether conditions favouring the disease are likely to continue (such as spring rains) or whether they are under the control of the turf manager (such as irrigation practices) and can be corrected quickly. The timing of treatment actions also depends on how the treatment affects the pathogen. For example, most fungicides work by preventing the pathogen from infecting healthy turf rather than by killing the pathogen directly. This means that in high risk sites, such fungicides would be used when there is a sound basis for expecting infection to occur.

Thresholds also depend on the category of site as mentioned in the section *2. Categorize the Sites*, on page 13.

For further information on pathogens, symptoms, disease cycle and suggested management of diseases that affect turf in Ontario, refer to *Diseases and Insects of Turfgrasses in Ontario*, OMAF Publication 162 (1996).

CONTROLS

Chemical Controls

Preferred fungicides are discussed in the section *Pesticides*, on page 34. Fungicides currently registered for use on turf in Ontario can be found in OMAF Publication 394, *Recommendations for Turfgrass Management*.

TAKE-ALL PATCH

One cultural practice that has been effective in managing take-all patch is the use of acidifying fertilizers, such as ammonium sulphate. Research into the mechanism of this treatment has revealed that under high pH conditions, there is more manganese available to the plant. Manganese is involved in the synthesis of compounds that protect grasses from take-all disease; it also affects root development. Researchers suggest that in high-pH soils, the microbes that prevent manganese uptake are more prevalent than those that convert manganese to a form that plants can use. As a result, bentgrasses may suffer from a manganese deficiency under high-pH conditions even though this micronutrient may be plentiful in the soil. Applications of foliar manganese have been found to reduce the severity of take-all when applied either in October or April at rates of 2.25 kg Mn/ha or higher of $MnSO_4$. Frequent applications of ammonium sulphate at low rates is the best cultural approach to managing take-all patch, because this fertilizer will lower soil pH and allow plants to take up manganese. Additional applications of manganese can also help reduce the severity of this disease.

ANTHRACNOSE BASAL ROT

Pathogen *Colletotrichum graminicola*

Hosts Reports have shown damage only on annual bluegrass and creeping bentgrass. In mixed turf, some grass species remain unaffected, whereas others are severely diseased. Often, either annual bluegrass or creeping bentgrass will be affected, but not both at the same time.

Symptoms Anthracnose basal rot differs from anthracnose blight in that it infects the crown of the plant and then spreads upward. It almost always results in the death of the plant. The symptoms, however, vary depending on the grass species affected. On annual bluegrass, symptoms appear as a bright yellowing of the turf in irregular patches. Affected bentgrass turf typically appears as irregular red or bronze patches. On individual plants infected with anthracnose basal rot, a dark brown or black colour is present at the base of the plant. As the disease worsens, the darkening (rotting) progresses up the stem and acervuli can be observed with a hand lens on stem and leaf tissue. On newly infected plants, a dark brown colour appears in the crown region before the foliage begins to turn a yellow or orange-to-bronze colour. By the time the discolouration appears on the foliage, rotting at the base is usually advanced, and the shoots can easily be separated from the crowns. Damage can expand to several square metres as the fungus continues to grow.

Disease Cycle The fungus responsible for anthracnose basal rot, *Colletotrichum graminicola*, survives the winter as dormant resting structures called sclerotia and as dormant mycelium in infected plant debris. During early spring outbreaks of anthracnose basal rot, the fungus, which may have overwintered in the plant, initiates infection at the base of the plant. Outbreaks of anthracnose basal rot can also result when spores produced in acervuli are dispersed by splashing water or tracked by mowing equipment from one area to another. Anthracnose is likely to occur when plants are growing slowly (during periods of hot and cold temperatures), during overcast periods, periods of high rainfall and in high humidity conditions. The disease typically favours temperatures of 10°C–20°C and high moisture in late spring and early summer. There is evidence to suggest that cultural practices such as aeration and topdressing that wound the plant play a role in the onset and the severity of the disease.

Management Proper fertilization and maintenance of good physical soil conditions are the most effective approaches to managing anthracnose basal rot. This disease is very often seen where one or more soil-related problems such as poor drainage, compaction or layering occur. Frequent, light applications of nitrogen are often helpful in managing this disease. Improved drainage and a regular aeration program will reduce excess soil moisture, alleviate compaction and improve root growth, creating conditions that are less favourable for anthracnose basal rot. Avoid aerating and topdressing during periods of high rainfall; the combination of the wounding of the turf, followed by wet conditions, is known to exacerbate the disease.

BIOLOGICAL CONTROL OF TURFGRASS DISEASES

Snow Moulds

Researchers at the University of Guelph have been working on a biological control system for turfgrass snow mould diseases. Work began in 1994 by looking for better strains of a fungus that could suppress grey snow mould disease caused by the fungi *Typhula ishikariensis* and *Typhula incarnata*. It was found that some strains of a fungus *Typhula phacorrhiza* could inhibit grey snow mould disease. As a result, strains of *T. phacorrhiza* were collected from corn fields across southern Ontario. By 1997, five strains had been identified from several hundred that worked as well as conventional fungicides at suppressing grey snow mould.

The fungus *Typhula phacorrhiza* is a close relative of the organisms that cause grey snow mould. It is referred to as a saprophyte, which is a type of organism that lives on dead organic matter. It can be found in regions that typically have abundant organic matter (such as forest litter) and at least a few weeks of snow cover or near-freezing temperatures. In Canada, this species is most commonly associated with corn stalk residue after snowmelt. It is a psychrophile, which means that it likes cold temperatures. In many ways, it is similar to the grey snow mould fungi but is not known to cause any turfgrass diseases.

The residual efficacy of the best *Typhula phacorrhiza* isolates was examined, and after five years of field testing, it was discovered that a single application of *Typhula phacorrhiza* in the first year can suppress grey snow mould disease for the next three years to an aesthetically acceptable level. In the fourth and fifth years, although suppression was still evident in some plots, the level of suppression was not aesthetically acceptable and less than that of fungicide check treatment.

Due to low fungicide susceptibility, it is possible to develop an integrated disease management program that incorporates both the use of conventional synthetic fungicides such as Arrest® and Tersan® along with *Typhula phacorrhiza*. Since 1999, researchers have been working on a registration package for *Typhula phacorrhiza*. The toxicology of this organism (i.e., whether it causes problems for humans and animals) has not been studied in any detail. There are no reports of this organism or any closely related organisms causing harm to humans or animals.

Additional research at the University of Guelph has shown that fall applications of compost provide good control of pink and grey snow mould. An application of 97.4 kg/100 m^2 gave the same level of control as the fungicide quintozene. In addition, compost-treated plots greened up more quickly than either the fungicide control plots or fertilizer treated plots.

Dollar Spot

Research at the University of Guelph has found that regular applications of Ringer Greens Super and Ringer Turf Restore significantly suppressed dollar spot. In these studies, however, they did not provide acceptable levels of dollar spot control. Multiple applications of compost (every 3 weeks) at a rate of 24.4 or 48.7 kg/100 m^2 reduced the severity of dollar spot to a level similar to 2-week applications of fungicide chlorothalonil.

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7. Safe Use Guidelines for Turf Pesticide Treatments

When you decide to use a pesticide, choose the best formulations and application methods for the situation. Take all possible precautions to prevent the exposure of people and non-target organisms to the pesticide. To limit the negative impacts of pesticides:

- Select the least-toxic pesticide that will do the job; if possible, use a "preferred pesticide" as defined in the section *Pesticides*, on page 34.
- Use application methods that minimize pesticide drift or spread in the environment.
- Use only a properly calibrated sprayer. (See the section *Sprayer Calibration*, below.)
- Limit treatments to only the plants or sites where pests are a problem (i.e., use spot treatments).
- Take precautions to prevent exposure of humans and non-target organisms to pesticides.

SPRAYER CALIBRATION

A very important part of integrated pest management, sprayer calibration:

- ensures that the proper amount of pesticide is applied
- ensures uniform pesticide application and coverage
- minimizes leftover tank mixtures, which can be difficult to dispose of

Field Boom-Type Sprayer Calibration

These five steps will help you calibrate your boom sprayer application rates in L/ha.

Instructions

1. Measure the time.
   - Place 2 stakes 50 m apart in the field.
   - Select the gear and throttle setting (rpm) at which you plan to spray. Half-fill the sprayer with water.
   - Drive the distance between the stakes three times, timing each pass. Each time, make sure the tractor is at the desired speed as you pass the first stake and maintain this speed until you pass the second stake.
   - Note the average time of the 3 passes.
2. Measure the average nozzle output.
   - Park the sprayer with the PTO engaged and the throttle adjusted to reach the PTO speed set in the test run.
   - Adjust the pressure regulator to the desired working pressure with full flow to the boom.
   - Collect the output from each nozzle for the average length of time needed to travel the 50 m in the test run.
   - Enter the nozzle outputs into the equation below.
   - Clean or replace any nozzle more than 5% above or below the average output.
   - Measure the nozzle spacing in metres.
   - Use the following formula to determine the sprayer output:

$$\text{Sprayer Output (L/ha)} = \frac{\text{Average Nozzle Output (mL)}}{\text{Nozzle spacing (m)}} \times 0.2$$

3. Calculate the actual area sprayed after each tank of spray solution is applied. Re-check the sprayer calibration after each tank of spray is applied by dividing the volume sprayed by the area sprayed. The nature of some products may slightly alter the calibration from that of clean water.

To measure in litres/acre or gallons/acre, use the following conversion guide.

Litres/ha x 0.4	=	L/ac
Litres/ha x 0.09	=	Imp. gal/ac
Litres/ha x 0.11	=	U.S. gal/ac

Sample Calculation

Average time to travel 50 m (164 ft)	=	24.5 sec
Average amount of liquid collected per nozzle for 24.5 sec	=	525 mL
Nozzle spacing on the boom	=	0.5 m (~20 in.)
Application rate = $\frac{525 \text{ mL} \times 0.2}{0.5 \text{ m}}$	=	210 L/ha
210 L/ha x 0.4	=	84 L/ac
210 L/ha x 0.09	=	18.9 Imp. gal/ac
210 L/ha x 0.11	=	23 U.S. gal/ac

Handheld/Backpack Sprayer Calibration

Many people use small, handheld spray guns or backpack sprayers for treating problem areas or spraying areas that were missed. Calibrating these sprayers is as important as calibrating your field sprayer.

Method I

1. Measure an area that is 100 m^2.
   e.g., 10 m x 10 m, or 25 m x 4 m.
2. Fill the spray tank with water. Mark the level on a measuring stick. Pump to the pressure that will be used during the pesticide application.
3. Spray the water over the 100 m^2 area. Walk at a steady pace, taking care to apply it as evenly as possible, just as you would when applying pesticide.
4. Measure the amount of water needed to refill the spray tank to the mark on the measuring stick. This amount will be the sprayer output per 100 m^2.

Method II

1. Set 2 stakes 50 m (164 ft) apart in the field.
2. Half-fill the sprayer with water.
3. Walk the 50 m three times at a steady pace. Calculate your average time to travel the 50 m.
4. Measure the width of the band sprayed by the nozzle (in metres) at your walking pace.
5. Pump the sprayer for the same amount of time as calculated in step #3, collecting the liquid from the nozzle in a measuring device.
6. Application rate (L/ha) $= \frac{\text{mL liquid per nozzle}}{\text{band width (metres)}} \times 0.2$

Method III

1. Partially fill sprayer. Pump to the pressure you will use during the pesticide application.
2. Spray to determine width of swath (in metres).
3. Walk at a steady pace for 15 sec. Measure the distance (in metres).
4. Multiply spray width times distance travelled to provide the area (in square metres) sprayed in 15 sec.
5. Spray into a measuring device for 15 sec to determine the amount of solution sprayed in 15 sec.
6. Application rate (L/ha) $= \frac{\text{amount sprayed}}{\text{area (length x width)}} = \frac{\text{L x 10,000}}{\text{sq. metres}}$

To convert the application rate of any pesticide to the amount required for a small area, follow this guide:

Dry measure:	1 kg/ha	=	10 gm/100 m^2
Liquid measure:	100 L/ha	=	1 L/100 m^2

Source: *Ontario Pesticide Education Program Manual* 1995.

PESTICIDE REGULATIONS

You must report all major spills, fires or thefts involving pesticides to the Ontario Ministry of the Environment at 1-800-268-6060. (Regulation 914, s.29)

Pesticide Schedules in Ontario

The Ontario Pesticide Advisory Committee is responsible for reviewing and recommending the placement of pesticide products into one of six schedules used to control the sale and use of the pesticides. See Table 7–1, *Pesticide Schedules*, on page 63 .

Certification and Training Requirements

You must be a certified grower or a licensed exterminator to buy and use Schedule 1, 2 or 5 pesticides. Assistants may also use these pesticides if they are trained and supervised as required.

Pesticide Certification for Ontario Farmers

Regulation 914 of the *Pesticides Act* requires that agriculturalists (growers) be certified to buy and use Schedules 1, 2 or 5 pesticides on land they farm. To become certified, agriculturalists must:

- attend the Grower Pesticide Safety Course (GPSC) and successfully complete the examination, and
- meet the definition of an "agriculturalist" as defined by Regulation 914 under the *Pesticides Act* (i.e., use farmland for agricultural or forestry production that falls within the farmlands property class under section 7 of the *Ontario Assessments Act*), and
- be at least 16 years of age

Training for Agricultural Assistants Using Schedule 2 or 5 Pesticides

All assistants must have formal pesticide safety training, recognized by the Ministry of the Environment, before they can handle or use Schedule 2 or 5 pesticides under the supervision of a certified grower.

- This applies to all assistants, including family members, farm employees and seasonal workers.
- Trained assistants do not have to write an exam.
- Trained assistants must be 16 years of age or older.
- There are two training options for assistants. Assistants can:
  - attend a Grower Pesticide Safety Course and not write the certification examination, or
  - attend an on-farm training session presented by a qualified trained assistant instructor.

TABLE 7–1.
Pesticide Schedules

Schedule	Who Can Use It	Pesticide Characteristics
1	• licensed exterminator • certified grower • only with approved permit	very toxic very persistent highly mobile
5	• licensed exterminator • certified grower • assistant agriculturist under supervision	very toxic very persistent highly mobile less toxic or less persistent alternative not available
2	• licensed exterminator • certified grower • trainee or technician under supervision (some restrictions apply) • assistant agriculturist under supervision	toxic persistent moderately mobile
3	• licensed exterminator • certified grower • trainee or technician • consumer	moderately toxic moderately persistent slightly mobile
4	• licensed exterminator • certified grower • trainee or technician • consumer	low toxicity non-persistent non-mobile containers < 1kg < 1L
6	• licensed exterminator • certified grower • trainee or technician • consumer	low toxicity non-persistent non-mobile containers > 1 kg > l L

- For more information and a listing of Grower Pesticide Safety Course session dates and locations, check the Ontario Pesticide Education Program Web site at www.ridgetownc.uoguelph.ca/opep/
- To register for a Grower Pesticide Safety Course anywhere in Ontario, or for information about trained assistants:
  - call: 1-800-652-8573,
  - fax: (519) 674-1589
  - e-mail: opep@ridgetownc.uoguelph.ca

Certification and Licensing for Commercial Pesticide Exterminators

For updates to training requirements under Regulation 914 of the *Pesticides Act*, refer to the Ministry of Environment Web site at www.ene.gov.on.ca/ or phone 1-888-565-4923.

If you plan to apply pesticides as a business, you must be a licensed exterminator.

This includes farmers who custom-apply pesticides for other farmers and charge a fee for this service. Licensed exterminators who are self-employed must hold an operator licence as well as the appropriate exterminator licence. Exterminator licences are valid for five years.

To become a licensed exterminator, you must:

- complete a home study course and certification exam through Ridgetown College, University of Guelph, **and**
- send proof of certification (letter of successful completion of the exam(s)) and a fee to the Ministry of the Environment to obtain your exterminator licence

Training for Technicians Working as Assistants to Licensed Exterminators

Assistants to licensed exterminators must become technicians to mix, load or apply all Schedule 3, 4 and 6 pesticides and most Schedule 2 pesticides (some restrictions apply), under the indirect supervision of a licensed exterminator. Technicians cannot mix, load or apply Schedule 1 or 5 pesticides. Technician cards are valid for two years.

To become a technician, you must:

- complete an MOE-approved academic course and exam, **and**
- complete practical training with a licensed exterminator

For more information about certification and licensing requirements for licensed exterminators and training for technicians, contact Ontario Pesticide Training & Certification:

- tel: 1-888-620-9999
- fax: (519) 674-1585
- Web site: www.ridgetownc.uoguelph.ca/optc

GENERAL PRECAUTIONS

Always read the label first!

- before you buy a pesticide
- before you begin to use a pesticide
- before you store a pesticide or dispose of it

Learn about the health hazards and toxic properties of the pesticide you are using. Consult the product label, Material Safety Data Sheet (MSDS) or manufacturer for this information. Check the company Web sites for MSDS information.

Protect Yourself When You Use Pesticides

- **Make sure someone knows** where you are working, what pesticides you are handling and how long you expect the job to take.
- **Post emergency numbers**, including the Poison Information Centre and Spills Action Centre near all of your telephones.
- **Keep a list of the names and the *Pest Control Products (PCP) Act* registration numbers** of all the pesticides you handle. Keep a file of the pesticide label booklets for all the products you use. Make sure that your co-workers and family members know where this list or file is in case of an accident.
- **Have plenty of clean water, soap and paper towels — and an extra set of gloves and coveralls — nearby at all times** in case pesticide contaminates your clothing or skin.
- **Wear the correct protective clothing and equipment, and be sure that all items are clean and in good repair** before you put them on.
- **Never smoke, chew tobacco, eat or drink when you handle pesticides.** Never carry tobacco or food in your clothes – and never leave tobacco, food or beverages in areas where you handle or store pesticides.
- **Change your clothes and wash your hands and face before you eat, drink or smoke.**
- **Wash your hands before you use the toilet, as well as after.** The skin in your groin area absorbs pesticides very easily.

Protect Other People, Livestock, Pets, Water and Sensitive Crops

- Buy and store only what you need.
- Prevent drift.
- Keep pesticides out of water.
- Clean up spills quickly and safely.
- Dispose of containers and waste pesticide safely.

Protect Bystanders

Take precautions to prevent exposure of bystanders to pesticides.

- Post notices in public areas stating where treatments are planned and have occurred. For specific information on applying pesticides to public lands, refer to the *Ontario Pesticides Act*, Regulation 914, at www.e-laws.gov.on.ca/.
- Apply pesticides during periods of lowest public activity, if possible (i.e., on weekends for school grounds; in the early morning for parks).
- Remove all objects from the area where pesticides will be applied.
- Avoid spraying areas near public roadways where schoolchildren may be present.
- Advise owners or occupants on private land what precautions they may take to prevent exposure such as staying off the sprayed area for 24 hours.

Preventing Accidental Release of Pesticides

- Keep spray equipment (power hoses, backpacks, etc.) locked in vehicles or compartments of service trucks when not in use and during transport.
- Be prepared to handle pesticide spills and other emergencies. Have a pesticide spill kit and emergency phone numbers readily available.
- Never dispose of pesticides, empty containers or excess mixed pesticide on the property or leave them behind for the client to deal with.

Preventing Property Damage From Pesticides

- Some pesticides can stain stucco and siding or cement sidewalks. Where there is a possibility that spray could land on such surfaces, check labels for precautions. If in doubt, test spray before applying the pesticide to the treatment area.

HUMAN HEALTH

Risks of Pesticide Use

Each time you handle a pesticide, you are at some risk. The amount of risk depends on two things — the toxicity of that pesticide and your exposure to it.

Risk = Toxicity x Exposure

Toxicity

Toxicity is a measure of how harmful or poisonous the pesticide is. There are 2 types of toxicity:

- **Acute toxicity** – the toxic response that results from a **single exposure** to the pesticide. The symbols and words on the front panel of a pesticide label give you information about the acute toxicity.

  Lethal dose 50% (LD_{50}) is a measure of acute toxicity. It is the dose (mg of product per kg of body weight) that will kill 50% of the test animals within a stated period of time (24 hours to 7 days). Those products with low LD_{50} ratings are highly toxic.

  There are no registered products for turf with a high acute toxicity.

- **Chronic toxicity** – the toxic response that results from repeated exposures to small doses of a pesticide over a longer period of time. These toxic effects may not appear for months or years after exposure to the pesticide. The symbols on the label do NOT give information about the chronic toxicity of the product. Use protective clothing and equipment to help reduce exposure and the risk of chronic effects.

Cholinesterase Blood Tests

Organophosphorus and *carbamate* pesticides can affect your nervous system. These pesticides can change your serum and red blood cell levels of an enzyme called acetyl cholinesterase. Your body uses this enzyme to transmit messages through your nervous system. If your cholinesterase levels fall, you can experience symptoms, including trembling, twitching, blurred vision, difficulty breathing and heart difficulties.

If you use any of the groups of pesticides listed below on a regular basis, you should have regular cholinesterase blood tests. Your family doctor can arrange these tests, and they are covered by OHIP. **Have your first test before you begin to handle these pesticides.** That will show the baseline (normal) cholinesterase level for your body. During the spray season, if you are spraying organophosphorus or carbamate insecticides regularly for several weeks, you should have a cholinesterase blood test every **seven to ten days**. If your cholinesterase level drops to below one-half of your baseline level, then you are showing signs of pesticide poisoning and **you must remove yourself from exposure** to these pesticides until your cholinesterase level returns to normal. Insecticides registered for use on turf that fall in the organophosphate and carbamate classes are carbaryl and diazinon.

Exposure

Exposure is a measure of the contact you have with the pesticide. You can be exposed to the pesticide in three ways.

- **Dermal exposure** occurs through your skin or eyes. The amount and rate of pesticide that may be absorbed depends on several things, including:
  - your skin condition. If your skin is moist, or if you have rashes, broken skin or scratches, pesticide will be absorbed more easily.
  - the part of your body that is exposed. Your eyes, genital area, scalp and ear canals absorb pesticides at a higher rate than your hands or arms. Your eyes absorb pesticides at a rate of 100%.
- **Respiratory exposure (inhalation)** occurs when you inhale small spray particles, dust, gases or vapours.
- **Oral exposure** occurs when a pesticide enters your mouth or you swallow a pesticide.

First Aid

Always protect yourself from injury first. Don't become another victim. Always put on protective clothing and equipment before you enter a contaminated area or handle a contaminated victim.

1. Check to see if the victim is breathing.
   If the victim is not breathing:
   - Straighten the victim's airway and check for breaths.
   - If the victim does not begin to breathe, administer artificial respiration until the victim begins to breathe on his or her own.
   - Do not contaminate yourself, especially if the victim has pesticide or vomit around his face

Read and Follow Pesticide Label Information

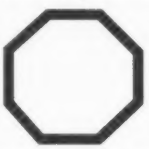
Know the Hazard Symbols and Words

Learn these symbols and words. They could save your life.

Four important symbols and words show the potential hazards of pesticides.

Hazard Symbol				
Signal Word	Poison	Corrosive	Flammable	Explosive

The hazard symbol will always appear inside one of the shapes shown below. These shapes and their warning words tell you the degree of hazard of the pesticide. The greater the number of sides to the shape, the more hazardous the product.

Warning Symbol			
	Triangle = low hazard (3 sides)	Diamond = moderate hazard (4 sides)	Octagon = high hazard (8 sides)
Signal Word	Caution	Warning	Danger

Check the label for special warnings about eye hazards and skin hazards. The front panel of the pesticide label may also contain warnings that tell you the product is corrosive to eyes, or is a skin or eye irritant.

or mouth. Use a face shield airway with a one-way valve. Do not breathe the exhaled air from the victim.

- Perform CPR if the victim's pulse disappears. You should only perform CPR if you are trained to do so.

If the victim is breathing, but unconscious:

- Place the victim in the recovery position (on the side with the head turned slightly to one side). If the victim vomits, try to keep the airway clear.
- **Stop the exposure to the pesticide.** Move the victim away from the contaminated area. Remove all contaminated clothing. Use soap and water to wash any skin exposed to the pesticide.
- Check the Four Basic Facts:
  - **What?** Identify the pesticide. Look for the label, container or leftover pesticide.
  - **How much?** How much product was the victim exposed to?
  - **Where?** How did the pesticide enter the body? Did it enter through the mouth, skin/eyes or lungs?
  - **When?** How much time has passed since the victim was exposed to the pesticide, and how long was the exposure? Were the symptoms immediate or did the poisoning occur as a result of using the pesticide over a longer period of time?

Don't waste time. If you can't answer these questions quickly, be ready to tell emergency personnel whatever you can.

2. Call an ambulance or the Poison Information Centre.
3. Start the first aid treatment appropriate for the route of entry.
4. Make sure the patient gets medical attention. First aid is not a substitute for professional medical help.

If symptoms of illness occur during or shortly after handling a pesticide, go to a hospital. Take the pesticide label, MSDS sheet or pesticide container with you. Do not transport the container in the passenger compartment of the vehicle. Refer to the Emergency Procedures for Pesticide Poisoning on the inside back cover.

Emergency Procedures for Pesticide Poisoning and First Aid Information

Refer to the inside back cover.

PERSISTENT HERBICIDES IN TOPSOIL

Some herbicides can persist in soil that is brought from farmer's fields to be used as topsoil for golf course, sports field or home lawn construction. To determine if there is a persistent herbicide present in the soil, you can conduct a bioassay. Place some of the soil in a pot and plant some perennial ryegrass seeds on the top of the soil. Keep the pot in a room with sunlight and keep the room temperature around 21°C. Make sure the soil stays moist until the seeds germinate. If there is a persistent photosynthetic inhibitor class of herbicide present in the soil, the seeds will germinate and then die within a day or two. If the perennial ryegrass seedlings die, do not use the topsoil. The topsoil can be stored until the herbicide has broken down. To determine if this has happened, perform another bioassay.

TOTAL NUMBER OF APPLICATIONS

Some product labels will state the total number of applications of that pesticide that can be made during a growing season. These limits prevent crop damage, soil residues or pest resistance.

PROTECTIVE CLOTHING AND EQUIPMENT

Choose and Wear the Appropriate Protective Clothing and Equipment

Make sure your protective clothing and equipment:

- is what you need for the job
- fits properly, and
- is clean and in good repair and working condition

The protective clothing and equipment you will need depends on:

- the pesticide you are using — Read the precautions section of the label to know what to wear.
- the job you are doing — For example, you need more protection when you handle concentrated pesticide or when you mix and load your sprayer.
- the type of application — For example, enclosed space or air blast sprayer applications made with open tractors require more equipment.

Each person who is working with pesticides needs **his or her own** set of protective clothing and equipment. Consult the technical expert at your safety supply company to make sure that you purchase the appropriate equipment and that it fits the user.

For ALL pesticides, always wear:

- a water-repellent hat, such as a hard hat or waterproof rain hat. Do not wear hats made from cloth.
  - Sometimes you need to protect your entire head and neck, for example, if you apply pesticides in a greenhouse, apply dusty formulations or use an air-blast sprayer. In these situations, wear a hood or hat that protects your ear canals. Do not wear hats made from cloth.
  - Baseball-style caps absorb pesticides and are not safe.

- long pants and a shirt with long sleeves or a coverall
  - Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. Disposable coveralls should be designated for pesticide use.
  - Water-resistent coveralls are preferred because cotton, denim and cotton/polyester pants cling to the skin if they get wet, increasing the risk of dermal exposure.

- chemical-resistant gloves (unlined)
  - Use neoprene or nitrile gloves (PVC), unless the label states otherwise. Do not wear rubber gloves, as many pesticides can break down the rubber material. Wear your gloves under your sleeves with the top cuffed.

- chemical-resistant boots (unlined)
  - Wear your pant legs over your boots to prevent pesticide from running down inside your boots.

Read the label. It will describe what extra protective clothing and equipment to wear. For some pesticides you may also need to wear:

- goggles
  - Use safety goggles with indirect vents so that splashes do not enter your eye. Regular eye glasses don't provide complete protection. Never wear contact lenses when you handle pesticides.

- face shield
- chemical-resistant apron
- respirator

- A respirator is a unit that covers your mouth and nose to prevent spray droplets, small particles and vapours from getting into your lungs. **A dust mask is not a substitute for a pesticide respirator.** Make sure you use cartridges and pre-filters that protect you against organic vapours. For more information about respirators, refer to the *Grower Pesticide Safety Course Manual*, Ridgetown College, University of Guelph.
- You may need more protection, such as canister gas masks or a self-contained breathing apparatus (SCBA) when you apply:
  - any pesticide in an enclosed area
  - fumigants, gases, vapours or smokes

When you work with fumigants, gases or vapours or when you apply any pesticide in an enclosed area, ALWAYS wear a respirator.

Use Organic Vapour Tractor Cab Cartridges

If you use a tractor with a cab when you spray, use tractor cab cartridges, which work the same way as an air-purifying respirator. These cartridges and pre-filters must be replaced and maintained on a regular basis to provide continued protection.

When you use air blast sprayers and mist blowers and tractors without cabs, wear the appropriate:

- respirator
- waterproof suit
- head covering
- chemical-resistant gloves
- boots
- eye protection

Once you complete the spray application, clean your protective equipment and the tractor. Do not operate the tractor without wearing protective clothing and equipment, unless it has been decontaminated.

Safety Supply Companies

Consult the safety supply companies of your choice for help in selecting your protective clothing and equipment. (See Table 7–2, *Safety Supply Companies in Ontario Providing Protective Clothing and Equipment*, on page 69.)

Care of Protective Clothing and Equipment

After you complete the spray operation, clean all protective clothing and equipment.

Never let children, pets or livestock come in contact with contaminated clothing or equipment. Also make sure that they cannot come into contact with the puddles of water left over from cleaning your equipment.

Wash your gloves with soap and water and leave them on to remove your other protective clothing and equipment.

Always remove protective clothing and equipment outdoors. If a granular pesticide was used, shake the clothing outdoors in a safe place, emptying pockets and cuffs.

Throw out clothing that has been contaminated by spills of highly toxic or concentrated pesticide. Place clothing in a plastic bag and take it to a landfill site.

Coveralls and other spray clothing must be washed separately from other clothes. They should be washed after each use. Place them in a plastic bag and keep them separate.

With your hands still protected by gloves, wash protective equipment. It is best to wash equipment outdoors. If you do not have an outside clean-up area, keep certain buckets just for equipment clean-up. Mark them and keep them in a special place. Wash the inside and outside of your goggles, hat, boots and any water-repellent clothing in warm, soapy water, rinse well and let them air-dry.

Remove the cartridges and pre-filters from the respirator.

Discard cartridges, canisters and filter pads when breathing becomes difficult, or when you notice a pesticide taste or odour, or at the interval set by the manufacturer.

- Make a note of the date the cartridge is first used.
- Remove cartridges and filter pads from the face piece and store in clean, sealed plastic bags.
- Wash the face piece in warm soapy water, rinse thoroughly and dry in a well-ventilated area.

TABLE 7–2.
Safety Supply Companies in Ontario Providing Protective Clothing and Equipment

3-M Canada Inc.	Occupational Health and Environmental Safety Box 5757 London, ON N6A 4T1	(519) 452-6165 1-800-364-3577 Fax: (519) 452-4660
Acklands Grainger	90 W. Beaver Creek Rd. Richmond Hill, ON L4B 1E7	(905) 731-5516 1-800-668-8989 Fax: (905) 731-2798
Aearo Canada	7115 Tomken Rd. Mississauga, ON L5S 1X7	(905) 795-0700 1-800-387-4304 Fax: (905) 564-5250
Dutch Industries "Protect-Air Cab Filter"	Huron Tractor, Box 1300 Exeter, ON N0M 1S3	(519) 235-1115 Fax: (519) 255-1939
HAMISCO	3392 Wonderland Rd. London, ON N6L 1A8	(519) 652-9800 1-800-668-9800 Fax: (519) 652-9661
Kappler Canada	Box 1687 20 Ryan Place Brantford, ON N3T 5V7	(519) 752-4369 1-800-387-9326 Fax: (519)752-2161
Levitt-Safety (Eastern) Limited	2872 Bristol Circle Oakville, ON L6H 5T5	(905) 829-3299 1-800-668-6153 Fax: (905) 829-2919
MSA Canada Inc.	148 Norfinch Dr. North York, ON M3N 1X8	(416) 667-9400 1-800-267-0672 Fax: (416) 663-5908
Mitt & Robe Co.	751 Norfolk St. N. Simcoe, ON N3Y 3R6	(519) 428-4050 1-877-893-6565 Fax: (519) 428-5142
Plant Products Co. Ltd.	314 Orenda Rd. Brampton, ON L6T 1G1	(905) 793-7000 1-800-387-2449 Fax: (905) 793-9632
Safety Express	4060B Sladeview Cres. Unit 2 Mississauga, ON L5L 5Y5	(905) 608-0111 1-800-465-3898 Fax: (905) 608-0091
The St. George Company (Suppliers of Kasco Helmets)	P.O. Box 430 20 Consolidated Dr. Paris, ON N3L 3T5	(519) 442-2046 1-800-461-4299 Fax: (519) 442-7191

Air-drying prevents damage to the inlet and outlet valves.

- Never use alcohol or other solvents for cleaning, as they will damage the rubber and plastic.

Next, wash the outside of your boots and gloves with soapy water and remove them.

After removing boots and gloves, wash them inside and out with detergent and water, rinse thoroughly and dry in a well-ventilated area.

Place all dry articles in a clean storage area until next use.

How to Wash Your Spraying Clothes

Never mix spray clothing with household laundry. Store and wash all clothing used for spraying separately from other clothing. Wash it after each use. **Remember to use chemical-resistant gloves to handle pesticide-contaminated clothing.**

- Presoak clothing before washing. Use one of three methods:
  - hose off garments outdoors
  - soak in separate tub or pail
  - use the prewash cycle in an automatic washer

- Place the clothing directly into the washing machine. Wash only a few garments at a time. Do not wash with other family clothes.
- Use hot water, the highest water level and the longest cycle, with heavy-duty detergent. Wash as you would for heavily soiled clothing.
- Wash clothing again.
- After washing, hang outside (preferably in bright sunlight) until completely dry. Do not use the clothes dryer.
- Clean the washing machine. Run the washing machine through one complete cycle using only detergent and hot water (without clothing).

Personal Hygiene

Always wash your hands before you eat, drink or smoke.

When you are finished for the day, take a bath or shower as soon as possible. The longer a pesticide remains on your skin, the greater the risk that it will be absorbed into your body.

Wash your hair and under your fingernails. Shower with lots of soap and water.

Always change into clean clothes.

Wear clean work clothes every day. A small spill on the previous day's clothes may seem unimportant, but wearing the same clothing again without washing it prolongs the exposure and increases your risk.

PROTECT THE ENVIRONMENT

Protect Contamination of Adjacent Land and Water Bodies

Do not allow pesticides to drift, run off or leach onto land or water bodies bordering treatment areas. Leave a suitable buffer zone between the treatment area and adjacent areas.

Buffer Zones

Buffer zones are areas left untreated to protect an adjacent area, for example a pond, a stream, a sensitive crop, a non-target crop, wetland or woodland, etc.

Protect Adjacent Land

No spray droplets should fall on adjacent properties, where treatments are not authorized. Areas of concern are:

- cultivated plants grown for human consumption
- plants sensitive to herbicide drift
- trees or shrubs that may be damaged by herbicides leaching to roots
- areas where children play

Protect Water Sources

- Use an anti-backflow device to prevent back-siphoning when drawing water from wells, ponds, streams or other sources.
- Mix pesticide and load the sprayer away from any water supply, including wells, ponds or streams.
- Use buffer zones (untreated areas) when you apply pesticides to avoid contaminating surface water, wells, ponds and/or streams, especially those containing fish. Check the product label for specific buffer zone distances. See *Setback Distances for Water Bodies*, below.
- Do not allow equipment rinse water and excess pesticides to run into sewers or ditches with water in them. Rinse water should be put into spray tanks and applied to the treatment area. Otherwise, it must be disposed of as hazardous waste through a hazardous waste disposal company. For more information, see the section *Disposal of Pesticides and Empty Pesticide Containers*, on page 71.
- Blow or sweep granular pesticides off driveways and hard surfaces, back into the turf, to prevent them from contaminating storm sewers.

Setback Distances for Water Bodies

It is an offence under the federal *Fisheries Act* to introduce any material into water that may be harmful to fish or fish habitat. To protect these waters, landscape applicators must determine a suitable setback distance between the area to be protected and the area where pesticide treatments are planned. The protected area includes the water body as well as adjacent riparian (riverbank) areas that contribute to fish food and habitat.

Reduce and Manage Pesticide Spray Drift

- Read the product label for information regarding buffer zones, water volumes and recommended nozzles.
- Use buffer zones around all watercourses and wells and neighbouring fields that contain sensitive crops. If the label does not state a specific buffer zone distance, leave an untreated area of natural vegetation.
- Select the recommended sprayer application rate (L/ha).
- Select the correct nozzle. Where practical, use air induction/venturi nozzles. These nozzles significantly reduce drift when compared to conventional nozzles.
- Select the correct nozzle-to-target distance.
- Spray only when winds are light to moderate (11 km/hr or less). If you notice drift is occurring because of the wind, **stop spraying** until the wind subsides. Do not apply pesticides if the wind is blowing towards susceptible crops or environmentally sensitive areas such as watercourses.
- Use spray plume protection where practical or available (hoods, shrouds, screens and air curtains).
- Use drift-reducing adjuvants in the spray tank as directed by the label.
- Utilize wick weeders, instead of spraying, when possible.
- Use non-volatile compounds.

For more information about spray drift, see the OMAF/Agriculture and Agri-Food Canada booklet *Best Management Practices — Pesticide Storage, Handling and Application* and the Ontario Pesticide Education Program (Ridgetown College) videos *How to Manage Spray Drift* and *Spray Drift Reduction Through Air Induction*.

PREVENT BEE POISONING

It is important to protect bees when you spray. Honeybees, as well as other bees and insects, are important pollinators of crops. Some turf areas have flowering weeds such as clover that offer bees important sources of pollen for honey production.

If you choose to use insecticides for insect control, take these steps to prevent harming bees when you spray:

- Before you apply a pesticide, advise local beekeepers, so that they can move colonies out of the danger area. Contact the Provincial Apiarist at 1-888-466-2372 for a list of the beekeepers in your area.
- Do not spray turf areas with flowering weeds such as clover on which bees are foraging. If you must apply insecticides, spray after 7 PM when the bees are not foraging. If this is not a possibility, spray before 7 AM. Bees usually do not forage at temperatures below 13°C.
- Do not apply insecticide on windy days to prevent drift toward any nearby hives.
- When there is a choice, choose the product formulation that is less hazardous to bees. Dusts are more toxic than sprays. WP formulations are more toxic than EC formulations.
- Under the *Bees Act*, it is an offence to spray in orchards while there is bloom on the trees.

Most organophosphate and carbamate insecticides are highly toxic to bees. Examples of insecticides used in crop production that are very toxic to bees are listed below:

Trade name	Common name
Diazinon	diazinon
Lorsban	chlorpyrifos
Sevin	carbaryl

Read each pesticide label for specific precautions regarding bees.

DISPOSAL OF PESTICIDES AND EMPTY PESTICIDE CONTAINERS

Triple or Jet Rinse Your Empty Pesticide Containers

Unrinsed pesticide containers are not really "empty." They may still hold about 1% of the original amount of pesticide. Although this figure sounds low, it is still a hazard to humans, animals and the environment. To reduce the hazard, rinse each container 3 times as the spray tank is filling. Use either the manual triple rinse technique or a specially designed device for rinsing containers. Paper or cardboard containers are often strong enough to be rinsed. If it is possible, rinse these containers as well as plastic ones.

Triple Rinse

To triple rinse:

1. Fill the empty container at least 10% full of the diluting material (usually water).

2. Cap, then shake or roll the container so that the inside surfaces of the container are well rinsed.
3. Pour rinsings into the spray tank.
4. Repeat steps 1–3 twice more.

Remember to check the container after you have finished rinsing. Make sure that no pesticide has been left behind as a cake or paste on the bottom of the container.

Rinsing Devices

Rinsing devices use pressurized water to clean out the container. They are just as effective as triple rinsing but take less time. Follow the manufacturer's instructions.

How to Dispose of Empty, Triple-Rinsed Containers

Never re-use empty pesticide containers. They may be handy, but there is still some risk, even if the containers are triple rinsed. Never give empty, rinsed containers to anyone, especially not children. Dispose of them promptly.

Regulation 914 of the *Pesticides Act* regulates how pesticide containers are to be disposed of in Ontario (Reg 914, s.27).

Metal, Plastic or Glass Containers

An empty metal, plastic or glass container that has been used to hold a Schedule 1, 2, 3*, 5 or 6* (*non-domestic) pesticide shall be disposed of by:

- triple rinsing or jet rinsing using clean water, or another appropriate solvent

AND either

- taking it for recycling to a Pesticide Container Depot

OR

- taking it to a licensed waste disposal site

Once containers are properly rinsed, they should be punctured to make it impossible to use them again and to make sure the rinse water is out of the container.

It is often more convenient to store empty, rinsed containers until you have collected enough to make a trip to the recycling Pesticide Container Depot or the waste disposal site. If you store containers, keep them in a dry safe place, such as the storage area, until you can dispose of them properly.

Recycling

The Ontario Pesticide Container Recycling Program is available to growers and commercial exterminators. Through this program, **clean, triple-rinsed, plastic/metal pesticide containers** (up to 23 L in size for plastic and 20 L in size for metal) can be returned to Pesticide Container Depots located throughout the province. To locate the Pesticide Container Recycling Depot closest to you, call the Ontario Pesticide Education Program at 1-800-652-8573.

Paper and Cardboard Containers

A paper or cardboard container that has been used to hold a Schedule 1, 2, 3*, 5 or 6* (*non-domestic) pesticide shall be disposed of by:

- triple rinsing or jet rinsing (if possible) using clean water;

AND either

- burning (if allowed by municipal bylaws), in circumstances that persons and animals are kept out of any smoke produced and any smoke is directed away from buildings, highways, roads or outdoor areas frequented by the public

OR

- taking it to a licensed waste disposal site

Paper or cardboard containers are often rigid enough to withstand rinsing. If it is possible, triple rinse these containers as you fill the tank. Then burn the containers in an isolated area on your farmland.

Be very careful around the smoke. It may contain toxic fumes from the burning pesticide. Be certain that there is no chance that a person or animal may breathe in this smoke. Make sure that the smoke does not drift toward buildings, roads or any public outdoor areas.

These containers can also be taken to a local waste disposal site as for metal, plastic or glass containers. If you can't dispose of them immediately, make sure containers are kept in a secure place such as the pesticide storage area.

Unwanted Pesticides

If you have pesticides that you do not need or cannot use, be sure to dispose of them safely.

- Contact the supplier. It is sometimes possible to return unused pesticide if it is still in its original container.
- If you cannot find any way to use the product as shown on the label, then the Ministry of the Environment requires that waste be disposed of by licensed waste haulers to a licensed waste disposal site. Look in the Yellow Pages of your telephone directory under "Liquid Waste Removal."
- Watch your local paper for "Municipal Hazardous Waste Collection Days" or contact your municipality. If your municipality has no waste collection days, encourage it to sponsor such an event. On these days, you can turn over surplus pesticide concentrates (maximum 25 L) for disposal.

Surplus Spray Mix

The best way to dispose of any excess spray mix is to find other fields that require an application of this pesticide. Before spraying, check the label to make sure the pesticide is registered for use on that crop.

If you can't find another field to spray, then dilute the remaining spray mix by adding 10 parts of water for each 1 part of spray mix. This diluted solution can be safely applied to the treated area as long as you do not exceed the pesticide rate recommended on the label. Be sure to check the label for any restrictions about crop rotation, days to harvest or surplus spray mix disposal.

NEVER re-spray the treated field with undiluted spray mix. Spraying an area twice will double the recommended pesticide rate. This may cause illegal pesticide residues in the harvested crop or harmful residues in the soil that can cause crop damage.

Soluble Packaging Options

Choose soluble packages that dissolve in the spray tank to reduce container disposal. Water-soluble packaging is used for dry flowable and wettable powder formulations of pesticides and is available under names such as Clean Pak, Solupak and Toss-N-Go. In most cases, the water-soluble packaging material is PVA (poly vinyl alcohol). This material dissolves completely when added to the water in the sprayer tank according to instructions.

Read all labels and instructions carefully. For more details, contact your vendor.

Keep soluble pouches dry until you add them to the spray tank:

- Do not handle pouches with wet hands or wet gloves.
- Do not remove pouches from the outer package until you are ready to add them.
- Always reseal the outer package to protect the remaining pouches from moisture.

Mixing Soluble Pouches

- Consult product labels for specific mixing instructions for each product.
- Fill the spray tank half full of water. With the agitator running, add the water-soluble pouches to the tank.
- Most pouches dissolve completely within 5 minutes, depending on the water temperature and the degree of agitation.
- As the tank continues to fill, add any other compatible pesticides.

Do not add:

- a pesticide that is incompatible with the PVA packaging material. The PVA material is not soluble with summer-type oils (e.g., Superior Oil).
- any material containing boron (e.g., Solubor), chelated micronutrients or water-soluble fertilizers. This combination is likely to cause a sticky, insoluble substance in the tank. If you apply boron, chelated micronutrients or water-soluble fertilizers, make sure that you completely empty and rinse the spray tank before you use any product packaged in PVA.

Storing Pesticides

Ontario's *Pesticides Act* and Regulation 914 give storage requirements for storage facilities. The storage requirements that you must follow depend on which schedules of pesticides that you store. See Table 7–3, *Pesticides Act Storage Requirements*, on page 74.

See also the OMAF Factsheet, *Pesticide Handling Facilities*, Order No. 94-037.

TABLE 7–3.
Pesticides Act Storage Requirements

	Schedule		
	3, 4, 6	2	1, 5
No contact with food or drink	♦	♦	♦
Does not impair health/safety	♦	♦	♦
Clean & orderly manner	♦	♦	♦
Warning signs posted on storage buildings	♦	♦	♦
Warning signs posted on unattended vehicles	♦	♦	♦
Emergency telephone numbers posted	♦	♦	♦
Ventilated to outside		♦	♦
Limited access (locked)		♦	♦
No floor drain		♦	♦
Safety equipment available		♦	♦
Area used exclusively for pesticides			♦

PESTICIDE SPILLS

Protect yourself before you begin to clean up any spill. Clean up spills immediately.

In the case of minor spills:

- For liquids, cover the spill with a thick layer of absorbent material such as kitty litter, vermiculite or dry soil. Sweep or shovel the material into a waste drum.
- For powders and granulars, sweep or shovel the material into a waste drum.

In the case of a major spill:

- Remove any people or animals from the spill area.
- Stop the spill from spreading.
- Do not let the pesticide enter any watercourse.

> If a pesticide spill causes, or is likely to cause, an adverse effect, you must notify the Ministry of Environment Spills Action Centre at 1-800-268-6060 (24 hr a day, 7 days a week) and the municipality.

For information on preventing spills, see the OMAF Factsheet, *Ways to Avoid Pesticide Spills*, Order No. 96-025. (See the page facing the table of contents for information on how to obtain factsheets.)

Application Procedures

Sprayers

- Sprayers that can deliver enough litres per hectare for adequate coverage are satisfactory for applying emulsion-type insecticides.
- If 2,4-D or related herbicides are used, clean the sprayers thoroughly with detergent containing ammonia to prevent crop damage.
- Adequate agitation is essential when applying wettable powder formulations.
- Pumps should be capable of delivering the flow and pressure required as well as being compatible with materials sprayed.
- Keep in mind that the higher the pressure, the greater the danger of drift to other crops.
- Calibrate your sprayer at least twice during the growing season with each set of nozzles used. The wear on nozzles and other parts will alter the amount of spray delivered.
- Check all nozzles for flow rate at least once a year. Replace nozzles when their output is 10% greater than rated output.
- For information on calibration, see the current OMAF Publication 75, *Guide to Weed Control*. See the calibration calculator on the OMAF Web site.

Aerial Application by Airplane or Helicopter

Any person who applies pesticide from an aircraft in Ontario **must** hold an aerial exterminator licence. In addition, a permit is required to purchase and apply pesticides by air for the following:

- applications to surface water, e.g., ponds, lakes, rivers (exceptions in some cases)
- applications to forests as defined in the *Crown Forest Sustainability Act*
- applications of any Schedule 1 or 5 pesticide or a Schedule 2 pesticide containing 2,4-D, 2,4-DB, mecoprop, MCPA, MCPB, dichlorprop, dicamba, picloram, paraquat or trichlopyr, except when applications are made to agricultural land

Be sure that any pesticide you apply by air has specific instructions for aerial use on the label.

Take extra precautions when using insecticides applied by air that are toxic to honeybees, such as Sevin (carbaryl).

Preventing Groundwater Contamination

Groundwater is the source of water for wells and springs. If groundwater becomes contaminated with pesticides, it is difficult to clean. Preventing groundwater contamination is crucial. Some pesticides have the potential to leach through the soil to groundwater. Movement of pesticides into groundwater can make the water unfit for use. However, pesticides applied to the soil are subjected to physical, chemical and biological processes that affect their movement through the soil and their potential for groundwater contamination. Pesticides applied to turf can be intercepted by the turfgrass plants themselves as well as by thatch. Making the right pesticide choices for the situation can help minimize the threat of groundwater contamination.

Soil Characteristics

Soil texture plays a major role in pesticide performance and persistence. Soil organic matter can make a difference in pesticide activity. Therefore, it is important to select a pesticide based on soil type and organic matter content. Chemicals tend to leach more readily in coarse-textured soils with low organic matter content. In contrast, fine-textured soils with high organic matter are highly adsorptive and therefore have a low leaching potential.

Pesticide Characteristics

Some pesticides bind strongly (adsorb) to soils and therefore are not easily removed. Clay materials and organic matter favour strong adsorption. Use soil analysis information on organic matter content when selecting pesticides and application rates for your pest management program. Some pesticides are highly soluble in water, which can increase their leaching potential. Leaching of a pesticide can be minimized by pesticide dosage and by the timing and method of application. Choose the right pesticide for your situation.

The rate of degradation by natural processes is highly dependent on both the pesticide class (chemistry) and environmental factors. Sunlight, temperature, soil, pH, microbial activity and other soil characteristics affect the breakdown of pesticide. Some pesticides break down slowly and therefore have a greater potential for leaching. On the other hand, short-lived pesticide may be degraded before any leaching occurs. Choosing a short-lived pesticide can minimize leaching potential. Microbial degradation occurs when fungi, bacteria and other soil microorganisms use pesticides as a food (energy) source. High organic matter, along with other properties such as optimum moisture, aeration, temperature and soil pH, can enhance microbial degradation. In addition, chemical degradation of pesticides can occur by reaction with water, oxygen and other chemicals. In general, pesticides that are highly water-soluble, relatively persistent and not readily adsorbed by soil have the greatest potential for leaching.

Water Table

High water tables may be vulnerable to contamination by pesticides and fertilizers due to the relatively short distance between the soil surface and groundwater. There is potential for groundwater contamination in areas with coarse-textured soils and high water tables. Specific application information for each pesticide is contained in the pesticide label. Careful adherence to application and disposal directions, combined with proper equipment calibration, provide the best method of preventing groundwater contamination.

Thatch Layer

Thatch is composed of both living and partially decayed leaves, roots, rhizomes and stolons. This layer of living and non-living material accumulates between the layer of green vegetation and the soil. The thickness of this layer is dependent upon the turfgrass species, environmental conditions and management practices. In a good growing environment, the rate of plant tissue accumulation often exceeds the rate of decay, resulting in the development of a moderate thatch layer. In general, a moderate thatch layer is beneficial for holding pesticides or nutrients. This prevents potential leaching through the thatch layer. Also, the organic matter in this layer increases as leaves, stems, roots and rhizomes decompose with time. This also helps with the binding of pesticides, thereby reducing potential leaching.

PROTECTING NON-TARGET VEGETATION FROM HERBICIDES

Precautions must be taken to prevent herbicides from being carried to the roots of non-target plants. This applies particularly to trees, because their roots usually extend a considerable distance from the trunk.

- Follow herbicide label directions that specify a buffer zone distance between the treatment area and non-target plants.
- If not specified on the label, herbicides should be applied no closer than 1 m out from the drip line of trees. The drip line is the outer edge of the leaf canopy, where water drops from the foliage and where a tree normally has many roots.
- Use of non-selective residual herbicides should be avoided in landscaped areas. Trees closer than two times the tree height can be severely damaged or killed.

LAND EXTERMINATION NOTIFICATION REQUIREMENTS FOR PUBLIC AND PRIVATE LAND

For specific information on land extermination notification requirements for public and private land refer to the *Ontario Pesticides Act*, Regulation 914 (www.e-laws.gov.on.ca/). Note that in some municipalities, bylaws restricting pesticide uses, banning pesticide use or requiring specific notification measures may be in effect. There are specific requirements on:

- what constitutes a public and a private area
- where notification signs should be posted
- what the posting signs should look like for public and private land and what information they must contain
- whether there are pre-posting requirements
- when the posting signs must be removed

PROFESSIONALISM AND PEST MANAGEMENT

A professional is someone with a high level of knowledge and training, who conducts his or her work effectively, responsibly and safely. Turf professionals should:

- have horticultural training and meet certification and licensing requirements for conducting business and for using pesticides (as applicable)
- belong to professional associations
- work at improving their knowledge and skills
- have well-maintained and calibrated equipment
- look after the welfare of clients by ensuring that services are correctly performed, taking precautions to prevent bystander exposure to pesticides and protecting the environment
- be able to apply an IPM approach to managing turf pests

Using Pesticides Professionally

- Always have a valid operator and landscape exterminator licence (as applicable).
- Know the federal and provincial regulations as well as municipal bylaws, if any, that apply to your work and follow them.
- Keep clear and accurate pesticide records. Complete the Daily Operation Records at the time of each treatment application.
- Honour any guarantees and be prepared to back up claims you make for your work. Don't make claims for pesticides or other products that are not true.
- Follow recommended pesticide safety and handling practices, wear protective clothing, mix and use pesticide products only according to instructions on the label and protect the environment and non-target areas from exposure to pesticides. Dispose of rinse water, waste pesticides and pesticide containers as required by provincial laws.

Communicating With Clients, Golfers or Users of Parks and Sports Fields

When working with private residence clients, golfers and park users, good communication is a vital part of integrated pest management. Time spent in determining customer needs and informing them about IPM will be time well spent. For example, the idea of paying for monitoring, especially when it shows that no controls are needed, will be new to some people. On golf courses and in parks, and for lawn care clients, taking time to explain that inspections and monitoring are important parts of an IPM program will help clients and end users realize that they are part of the pesticide reduction solution.

Suggestions for other things to discuss with clients:

- Before starting any work, make sure you understand exactly what the client or customer wants done. If expectations are unrealistic or if unexpected problems arise, discuss the difficulty honestly with the client.
- Provide clear quotes and letters of agreement, describing the work accurately, the fees and expenses, work schedule, standards required and payment schedule.
- Provide clients, golf course members and park users with information about the IPM approach and benefits, outlining cultural practices that may control confirmed pests.

- Find out what they want their turf to look like and whether the appearance of some parts of the landscape, such as the front yard, is more important than that of other areas. This will help in setting threshold and injury levels (e.g., some homeowners will not tolerate any weeds in their front yard).
- Find out whether they have concerns about how pest problems are managed. For example, some clients do not want pesticides used in their landscapes or in some parts of it, such as on lawns where children play.
- Determine the budget the client has available for the work and adapt the service to fit the budget goals.
- Let the client know what to expect from the different types of controls. For example, if biological controls are going to be released, make sure the client knows how they work and that it can take longer to see results than using pesticides.
- Explain the difference between damage that harms the turf and damage that affects the visual appearance temporarily but does not cause long term harm to the turf. Most clients will tolerate minor injury if the plant is not at risk.
- After each visit, send or leave the client a written notice of work done and other key information about their landscape.

Suggestions for communicating with golfers and end users about IPM:

- Explain, via newsletters or signage, about monitoring and its purpose.
- Communicate about any thresholds that are used so that there are reasonable expectations of turf quality.
- Explain the cultural practices that you are using to reduce pesticide inputs.
- Communicate pesticide reduction goals and successes.

VOLUNTARY INTEGRATED PEST MANAGEMENT ACCREDITATION PROCESS: A NEW INDUSTRY INITIATIVE

Purpose

The IPM accreditation process will help reduce reliance on pesticides through the application of integrated pest management (IPM) and plant health care (PHC) principles, with particular emphasis on the implementation of:

- cultural practices that promote optimum plant health
- pest prevention
- application of pesticides only when necessary
- use of reduced-risk products

The IPM accreditation process will accredit individuals and companies and/or organizations that demonstrate commitment to the principles of IPM. IPM is an approach that uses all available techniques in an organized process to suppress pest populations in effective, economical and environmentally safe ways.

Accreditation will be achieved through a process of education, an examination, ongoing professional development, proven dedication to the principles of IPM and a commitment to a code of practice and an audit. More details on this program can be obtained from the IPM/PHC Council of Ontario at www.planthealthcare.ca, tel: (905) 875-1805.

References

Bhowmik, P., et al. *1999 Professional Guide for IPM in Turf for Massachusetts.* Amherst: University of Massachusetts.

Leslie, A.R. 1994. *Handbook of Integrated Pest Management for Turf and Ornamentals.* Lewis Publishers, 2000 Corporate Boulevard, N.W., Boca Raton, Florida, 33431. Tel: (800) 272-7737, Fax: (800) 374-3401.

Plant Health Care (PHC)/Integrated Pest Management (IPM) Accreditation Process. 2002. IPM/PHC Council of Ontario. Tel: (905) 875-1805.

8. Appendices

APPENDIX A.
Turf Scouting Record

Date _____ **Scout Name** _____ **Site Location** _____

Green or Tee _____ **Playing Field** _____ **Home Lawns** _____

CONTACT INFORMATION

Name: _____

Address: _____

_____

Phone: _____

SITE EVALUATION

Age of turf: _____

Seed or sod: _____

Sun/shade: _____

	H	M	L
Compaction	❑	❑	❑
Thatch layer	❑	❑	❑
Soil type	❑	❑	❑

TURF SPECIES

Kentucky blue	❑	Tall fescue	❑
Bentgrass	❑	Annual bluegrass	❑
Fine fescue	❑	Perennial ryegrass	❑

Comments _____

_____

_____

_____

_____

ABBREVIATIONS

Disease	Abb.	Insect	Abb.
Anthracnose	A	Annual B. weevil	AW
Brown patch	BP	Black turfgrass ataenius	BT
Dollar spot	DS	Blue billbug	BB
Fusarium patch	F	Chinch bug	CB
Grey snow mould	GS	Cutworm	C
Leaf spot	LS	European chafer	EC
Patch disease	PD	European cranefly	ECF
Pink snow mould	PS	Japanese beetle	JB
Red thread	RT	June beetle	JuB
Rust	R	Unknown/other	OI
Unknown/other	OD		

Pest Management Unit Map

Instructions

1. Use a separate data sheet each time you scout a specific pest management unit.

2. Record the date, name of scout, site location and type of pest management unit: golf hole, sports field, home lawn.

3. Include a contact name and phone number.

4. Note the turf specie/species present.

5. Document as much information about the site as possible: age of turf, seed vs. sod, shade vs. sun, compaction, soil texture and thatch.

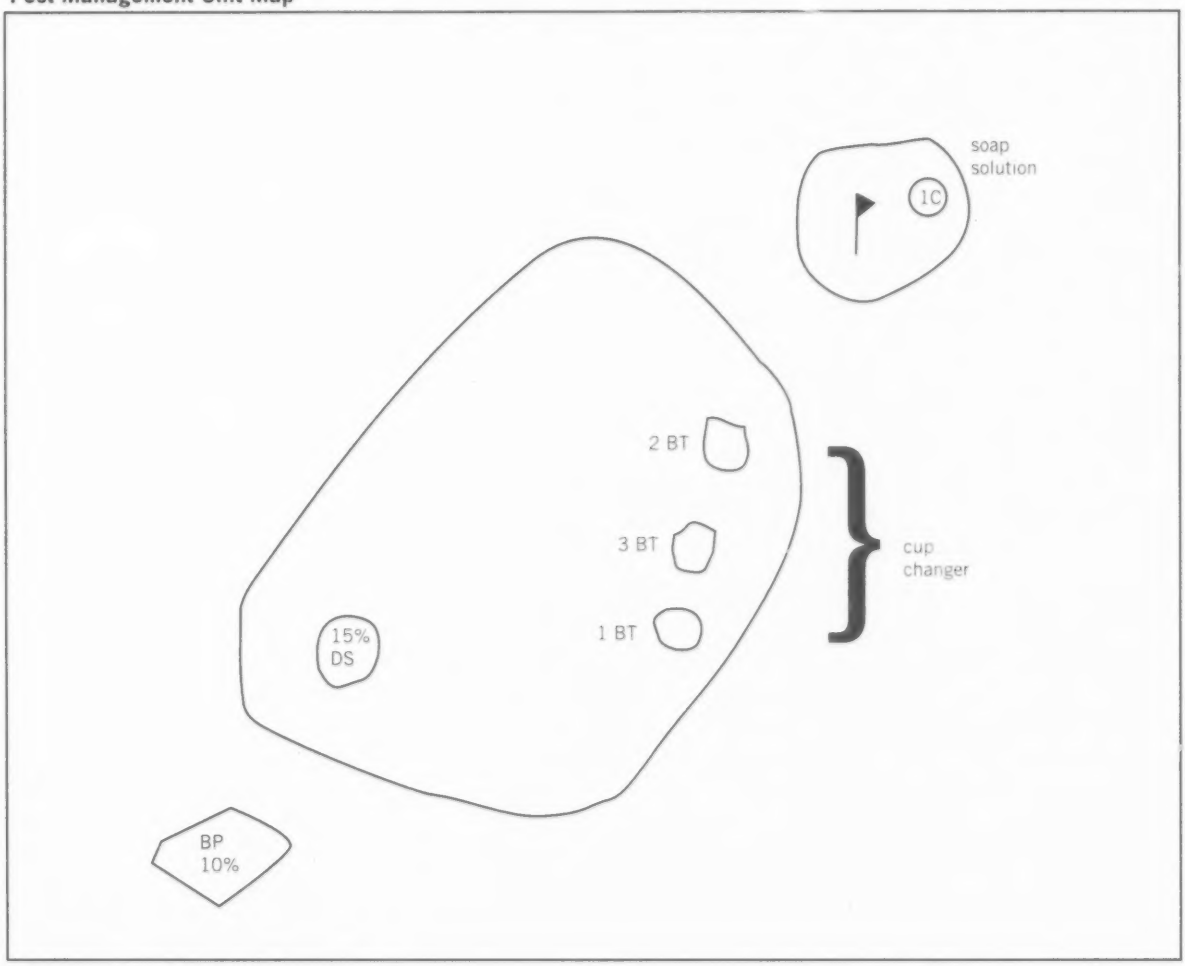
6. Add comments on prevailing weather that may have influenced pest development.

7. Draw a diagram of the pest management unit in the box. (See sample on the next page.)

8. As you walk or ride in a serpentine pattern across the unit, mark the areas of disease by drawing the perimeter of the affected area. Use the abbreviations supplied to indicate which disease/insect is present. Estimate the percentage of area affected and mark it on the map.

9. When specific insect monitoring teachniques are used, record the technique and the results on the map. For example, soap flush — 3 sw. If using the cup changer for grub detection, note the number of grubs present and species for each cup changer.

Pest Management Unit Map



APPENDIX B.
Golf Course Pest Scouting Form

DATE _____ **Cloud/Sun** _____ **Soil Temperature** _____

WEATHER _____ **Relative Humidity** _____

Temperature: High _____ **Low** _____ **Precipitation: Type** _____ **Amount** _____

Cultural/Chemical Controls _____

Hole	GREENS			TEES			FAIRWAYS			ROUGHS		
	Disease	Insect	Weed	Disease	Insect	Weed	Disease	Insect	Weed	Disease	Insect	Weed
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
P.G.[1]												
P.R.[1]												

[1] P.G. = putting green; P.R. = practice range

Legend

Diseases				Insects		Weeds	
Anthracnose foliar blight	AFB	Pink snow mould	PSM	Annual bluegrass weevil	ABW	Algae	A
Anthracnose basal rot	ABR	Pythium blight	PB	Aphodius	AP	Annual bluegrass	AB
Brown patch	BP	Pythium root rot	PRR	Black cutworm	BCW	Chickweed	C
Dollar spot	DS	Red thread	RT	Black turfgrass ataenius	BTA	Clover	Cl
Fairy ring	FR	Rusts	R	Bluegrass billbug	BB	Crabgrass	Cr
Fusarium patch	FP	Summer patch	SP	European chafer	EC	Dandelion	D
Grey snow mould	GSM	Slime moulds	S	European crane fly	ECF	Knotweed	K
Leaf spots	LS	Smuts	SM	Hairy chinch bug	HCB	Medic	M
Necrotic ring spot	NRS	Take-all patch	TAP	Japanese beetle	JB	Moss	Mo
Powdery mildew	PM	Yellow patch	YP	June beetle	JuB	Plaintain	P
		Other	OD	Sod webworm	SW	Quackgrass	Q
				Turfgrass scale	TS	Spurge	Sp
				Other	OI	Yarrow	Y
						Other	OW

APPENDIX C.
Pesticide Application Record

CHEMICAL APPLICATION

Date _____ Time _____

Pest _____ Area Treated _____

Equipment Used _____ Operator _____

	Product	Preventative	Curative	Rate (ml/100 m^2)	Rate (g/100 m^2)	Amount of Product Used
A						
B						
C						

Effectiveness of Treatment: _____

APPENDIX D.
Useful Equivalents for Converting Sampling Areas

Dimensions (centimetres)		Area (metres^2)		Dimensions (inches)		Area (ft^2 or yd^2)
100 x 100 cm	=	1 m^2	≈	40 x 40 in.	≈	(over) 1 yd
30 x 30 cm	≈	0.1 m^2	≈	12 x 12 in.	=	1 ft^2
15 x 15 cm	=	0.025 m^2	≈	6 x 6 in.	=	0.1 yd^2

Golf cup cutter plug: 11 cm in diameter ≈ 0.01 m^2 (4.25 in. in diameter ≈ 0.1 ft^2)
(Note: ≈ means "approximately").

APPENDIX E.
OMAF Turf Agriphone

Available from April through September, the Turf Agriphone (toll-free: 1-888-290-4441) offers a 5-minute recorded message, updated weekly, containing up-to-date information on turf diseases, insects and weed infestations.

APPENDIX F.
Resources

Publications

Compendium of Turfgrass Diseases, 2nd Edition. 1992. R.W. Smiley, P.H. Dernoeden, and B.B. Clarke. American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota, 55121-2097. Tel: (800) 328-7560 Fax: (612) 454-0766

Diagnostic Turfgrass Management for Golf Greens. 1994. T. Mascaro. Turfgrass Products Publications, Oakland Park, Florida.

Diseases and Insects of Turfgrasses in Ontario. 1996. Ontario Ministry of Agriculture and Food Publication 162.

Healthy Lawn Tips. 2002. Pest Management Regulatory Agency, 2720 Riverside Drive, Ottawa, Ontario,K1A 0K9. Tel: 1-800-267-6315 Fax: (613) 736-3798 www.healthylawns.net

Management of Turfgrass Diseases, 2nd Edition. 1994. J.M. Vargas. Lewis Publishers, 2000 Corporate Boulevard N.W., Boca Raton, Florida, 33431. Tel: (800) 272-7737 Fax: (800) 374-3401

Managing Turfgrass Pests. 1994. T.L. Watschke, P.H. Dernoeden, D. Shetlar. Lewis Publishers, 2000 Corporate Boulevard, N.W., Boca Raton, Florida, 33431. Tel: (800) 272-7737 Fax: (800) 374-3401

Ontario Weeds. 1992. Ontario Ministry of Agriculture and Food Publication 505.

Protocols for an IPM System on Golf Courses. 2000. University of Massachusetts Extension

Scotts Guide to the Identification of Turfgrass Diseases and Insects. 1987. O.M. Scott & Sons Company, Marysville, Ohio, 43041 ($20.00, 1-800-543-0006).

The Microscope in Turfgrass Disease Diagnosis. P. Sanders. Turf Education Associates, c/o Patricia Sanders, 4545 Galen Drive, State College, Pennsylvania, 16803.

Turfgrass Ecology and Management. T.K. Danneberger. Lawn and Landscape Maintenance, 4012 Bridge Avenue, Cleveland, Ohio, 44113. Tel: (800) 456-0707

Turfgrass Insects of the United States and Canada. Second Edition. 1999. Patricia J. Vittum, Michael G. Villani, Haruo Tashiro. Cornell University Press, New York.

Turfgrass Management Recommendations. 2002. Ontario Ministry of Agriculture and Food Publication 384.

Videos

Integrated Pest Management in Turf. Ontario Ministry of Agriculture and Food, 1 Stone Road West, Guelph, Ontario, N1G 4Y2. Tel: (519) 826-3700 Fax: (519) 826-3633

Identifying Turfgrasses. Independent Study, University of Guelph, Guelph, Ontario, N1G 2W1. Tel: (519) 767-5050 Fax: (519) 824-9813

Integrating Naturalized Areas on the Golf Course. Independent Study, University of Guelph, Guelph, Ontario, N1G 2W1. Tel: (519) 767-5050 Fax: (519) 824-9813

Spraying Turf Pests. Independent Study, University of Guelph, Guelph, Ontario, N1G 2W1. Tel: (519) 767-5050 Fax: (519) 824-9813

Resources

Ontario Ministry of Agriculture and Food Turf Agriphone – 1-888-290-4441 (April through September)

Guelph Turfgrass Institute Advisor, a bimonthly turf newsletter. To subscribe, e-mail: advisor@gti.uoguelph.ca

APPENDIX G.
Accredited Soil-Testing Laboratories in Ontario

The following labs are accredited to perform soil tests for pH, buffer pH, P, K, Mg and Nitrate-N on Ontario soils.

Laboratory Name	Address	Telephone/Fax/E-mail	Contact
A & L Canada Laboratories East Inc. Web site: www.al-labs-can.com	2136 Jetstream Rd. LONDON, Ont. N5V 3P5	Tel: (519) 457-2575 Fax: (519) 457-2664 E-mail: aginfo@al-labs-can.com	Mr. Greg Patterson Mr. Ian McLachlin
Accutest Laboratories Web site: www.accutestlabs.com	146 Colonnade Rd., Unit #8 NEPEAN, Ont. K2E 7Y1	Tel: (613) 727-5692 Fax: (613) 727-5222 E-mail: phaulena@accutestlabs.com	Mrs. Lorna Wilson Mr. Peter Haulena
Agri-Food Laboratories Web site: www.agtest.com	503 Imperial Rd., Unit #1 GUELPH, Ont. N1H 6T9	Tel: (519) 837-1600 1-800-265-7175 Fax: (519) 837-1242 E-mail: lab@agtest.com	Mr. Dale Cowan Ms. Nora Wilson
Brookside Laboratories, Inc.	301 South Main St. NEW KNOXVILLE, Ohio, US 45871	Tel: (419) 753-2448 Fax: (419) 753-2949 E-mail: nfisher@blinc.com	Ms. Nicole Fisher Mr. Mark Flock
Soil and Nutrient Laboratory	University of Guelph P.O. Box 3650, 95 Stone Rd. W. GUELPH, Ont. N1H 2W1	Tel (519) 767-6226 Fax: (519) 767-6240 E-mail: vkerslak@lsd.uoguelph.ca	Ms. Virginia Kerslake
Stratford Agri Analysis (A Daco Laboratories Ltd.)	1131 Erie St., Box 760 STRATFORD, Ont. N5A 6W1	Tel: (519) 273-4411 1-800-323-9089 Fax: (519) 273-4411 E-mail: saa@dacolabs.com	Mr. Dale Peters Mr. Keith Lemp

There is no official accreditation in Ontario for tissue analysis, but all the accredited soil-testing labs are monitored for proficiency on tissue analyses.

APPENDIX H.
The Metric System

Metric Units

Linear Measures (length)		
10 millimetres (mm)	=	1 centimetre (cm)
100 centimetres (cm)	=	1 metre (m)
1,000 metres	=	1 kilometre (km)
Square Measures (area)		
100 m x 100 m = 10,000 m^2	=	1 hectare (ha)
100 ha	=	1 square kilometre (km^2)
Cubic Measures (volume)		
Dry Measures		
1,000 cubic millimetres (mm^3)	=	1 cubic centimetre (cm^3)
1,000,000 cm^3	=	1 cubic metre (m^3)
Liquid Measures		
1,000 millilitres (mL)	=	1 litre (L)
100 L	=	1 hectolitre (hL)
Weight-Volume Equivalents (for water)		
(1.00 kg) 1,000 grams	=	1 litre (1.00 L)
(0.50 kg) 500 g	=	500 mL (0.50 L)
(0.10 kg) 100 g	=	100 mL (0.10 L)
(0.01 kg) 10 g	=	10 mL (0.01 L)
(0.001 kg) 1 g	=	1 mL (0.001 L)
Weight Measures		
1,000 milligrams (mg)	=	1 gram (g)
1,000 g	=	1 kilogram (kg)
1,000 kg	=	1 tonne (t)
1 mg/kg	=	1 part per million (ppm)
Dry-Liquid Equivalents		
1 cm^3	=	1 mL
1 m^3	=	1,000 L

Calculating Parts per Million (ppm)		
1 ppm	=	1 g active ingredient per 1,000 L water
Handy Metric Conversion Factor		
litres per hectare x 0.4	=	litres per acre
kilograms per hectare x 0.4	=	kilograms per acre

Application Rate Conversions

Metric to Imperial (Approximate)		
litres per hectare x 0.09	=	gallons per acre
litres per hectare x 0.36	=	quarts per acre
litres per hectare x 0.71	=	pints per acre
millilitres per hectare x 0.015	=	fluid ounces per acre
grams per hectare x 0.015	=	ounces per acre
kilograms per hectare x 0.89	=	pounds per acre
tonnes per hectare x 0.45	=	tons per acre
Imperial to Metric (Approximate)		
gallons per acre x 11.23	=	litres per hectare (L/ha)
quarts per acre x 2.8	=	litres per hectare (L/ha)
pints per acre x 1.4	=	litres per hectare (L/ha)
fluid ounces per acre x 70	=	millilitres per hectare (mL/ha)
tons per acre x 2.24	=	tonnes per hectare (t/ha)
pounds per acre x 1.12	=	kilograms per hectare (kg/ha)
ounces per acre x 70	=	grams per hectare (g/ha)

Liquid Equivalents

Litres/Hectare		*Approximate Gallons/Acre*
50	=	5
100	=	10
150	=	15
200	=	20
250	=	25
300	=	30

Dry Weight Equivalents

Grams or Kilograms / Hectare		*Ounces or Pounds /Acre*
100 grams	=	1½ ounces
200 grams	=	3 ounces
300 grams	=	4¼ ounces
500 grams	=	7 ounces
700 grams	=	10 ounces
1.10 kilograms	=	1 pound
1.50 kilograms	=	1½ pounds
2.00 kilograms	=	1¾ pounds
2.50 kilograms	=	2¼ pounds
3.25 kilograms	=	3 pounds
4.00 kilograms	=	3½ pounds
5.00 kilograms	=	4½ pounds
6.00 kilograms	=	5¼ pounds
7.50 kilograms	=	6¾ pounds
9.00 kilograms	=	8 pounds
11.00 kilograms	=	10 pounds
13.00 kilograms	=	11½ pounds
15.0 kilograms	=	13½ pounds

Metric Conversions		
5 mL	=	1 tsp
15 mL	=	1 tbsp
28.5 mL	=	1 fl. oz

Conversion Tables
Metric to Imperial (approx.)

Length		
1 millimetre (mm)	=	0.04 inch
1 centimetre (cm)	=	0.40 inch
1 metre (m)	=	39.40 inches
1 metre (m)	=	3.28 feet
1 metre (m)	=	1.09 yards
1 kilometre (km)	=	0.62 mile
Area		
1 square centimetre (cm^2)	=	0.16 square inch
1 square metre (m^2)	=	10.77 square feet
1 square metre (m^2)	=	1.20 square yards
1 square kilometre (km^2)	=	0.39 square mile
1 hectare (ha)	=	107,636 square feet
1 hectare (ha)	=	2.5 acres
Volume (dry)		
1 cubic centimetre (cm^3)	=	0.061 cubic inch
1 cubic metre (m^3)	=	1.31 cubic yards
1 cubic metre (m^3)	=	35.31 cubic feet
1,000 cubic metres (m^3)	=	0.81 acre-foot
1 hectolitre (hL)	=	2.8 bushels
Volume (liquid)		
1 millilitre (mL)	=	0.035 fluid ounce
1 litre (L)	=	1.76 pints
1 litre (L)	=	0.88 quart
1 litre (L)	=	0.22 gallon (Imp.)
1 litre (L)	=	0.26 gallon (U.S.)
Weight		
1 gram (g)	=	0.035 ounce
1 kilogram (kg)	=	2.21 pounds
1 tonne (t)	=	1.10 short tons
1 tonne (t)	=	2,205 pounds
Pressure		
1 kilopascal (kPa)	=	0.15 pounds/in^2
Speed		
1 metre per second	=	3.28 feet per second
1 metre per second	=	2.24 miles per hour
1 kilometre per hour	=	0.62 mile per hour
Temperature		
°F	=	(°C X 9/5) + 32

Conversion Tables
Imperial to Metric (approx.)

Length		
1 inch	=	2.54 cm
1 foot	=	0.30 m
1 yard	=	0.91 m
1 mile	=	1.61 km
Area		
1 square foot	=	0.09 m^2
1 square yard	=	0.84 m^2
1 acre	=	0.40 ha
Volume (dry)		
1 cubic yard	=	0.76 m^3
1 bushel	=	36.37 L
Volume (liquid)		
1 fluid ounce (Imp.)	=	28.41 mL
1 pint (Imp.)	=	0.57 L
1 gallon (Imp.)	=	4.55 L
1 gallon (U.S.)	=	3.79 L
Weight		
1 ounce	=	28.35 g
1 pound	=	453.6 g
1 ton	=	0.91 tonne
Pressure		
1 pound per square inch	=	6.90 kPa
Temperature		
°C	=	(°F – 32) x 5/9

Abbreviations

%	= per cent (by weight)	km	= kilometre
ai	= active ingredient	km/h	= kilometres per hour
AP	= agricultural powder	kPa	= kilopascal
cm	= centimetre	L	= litre
cm^2	= square centimetre	m	= metre
DG	= dispersible granular	m^2	= square metre
DP	= dispersible powder	mL	= millilitre
E	= emulsifiable	mm	= millimetre
EC	= emulsifiable concentrate	m/s	= metres per second
e.g.	= for example	SC	= sprayable concentrate
F	= flowable	SP	= soluble powder
g	= gram	t	= tonne
Gr	= granules, granular	W	= wettable (powder)
ha	= hectare	WDG	= water dispersible granular
kg	= kilogram	WP	= wettable powder

APPENDIX I.
Glossary

actinomycete — literally "ray fungi," filamentous bacteria. Actinomycetes typically live off dead material, especially in soil , but a few are pathogenic to man, animals and plants.

auxins — a group of plant growth substances, the most common example being indole acetic acid (IAA), responsible for raising the pH around cells, making the cell wall less rigid and allowing elongation.

bacteria — (bacterium, singular). Minute unicellular organisms that lack chlorophyll and are the chief agents of fermentation, putrefication and decay. Many are pathogenic on plants.

buffer zone — an area of land between a sensitive area and the pesticide treatment area, where pesticides are not applied. The buffer zone must be wide enough to ensure spray, drift and run-off will not reach sensitive areas.

carbohydrate — a class of organic compounds, including sugars and starches.

chlorotic — yellowing of normally green tissue due to chlorophyll destruction or failure of chlorophyll formation.

cytokinin — a class of plant growth regulators that cause cell division, cell differentiation, shoot differentiation, etc.

ecosystem — a functioning community of nature that includes fauna and flora, together with the chemical and physical environment with which they interact. Ecosystems vary greatly in size and characteristics; an ecosystem can be a mud puddle, a field or orchard, or a forest. An ecosystem provides a unit of biological study and can be a unit of management.

endophyte — any organism growing within another plant.

entomogenous — growing in or on an insect.

enzyme — an organic catalyst, normally a protein formed and secreted by a living cell.

evapotranspiration — the process by which water is evaporated from a turf area.

frass — solid larval insect excrement.

guttation fluid — plant sap that exudes from a cut leaf or stem surface, or from a natural opening in the leaf under humid conditions. It is rich in sugars that can be a source of food for some microbes.

grub — the larval stage of beetles.

host — a plant that can be invaded by a pathogen and from which the pathogen obtains its nutrients.

hypha — (hyphae, plural) a single strand of mycelium.

inoculation — the coming into contact of a pathogen with a plant.

inoculum — the pathogen or its parts that can cause infection.

instar — stage of insect between molts.

larva — a young insect that has hatched and is in an immature form (e.g., caterpillar, maggot, grub, slug).

lesion — a localized area of discoloured, diseased tissue.

metabolite — a by-product of metabolism or a substance that is essential to the metabolism of an organism or to a metabolic process.

microbe — microscopic organisms such as bacteria, algae, diatoms, plankton and fungi.

molt — to cast off or shed the outer skin at certain intervals prior to replacement of the cast-off parts by a new growth.

mycelium — (mycelia, plural) the mass of filamentous strands of hyphae that make up the body of the fungus.

nematodes — generally microscopic, wormlike animals that live in water or soil or as parasites of plants and animals.

pathogen — a disease-causing organism.

pesticide — any material that is used to kill, control and manage pests, including insecticides, fungicides, herbicides, nematicides and rodenticides.

Pest Management Regulatory Agency — an agency of Health Canada that is responsible for registering pesticides in Canada.

pH — a measure of acidity or alkalinity in soil or water based on a negative logarithmic scale. Ranges from 1–14, with 7 being neutral.

phenology — a branch of science dealing with the relations between climate and periodic biological phenomena.

pheromone — any substance secreted by an insect that influences the behaviour of the other individuals of the same insect species.

photodegradation — broken down by sunlight.

phytotoxic — toxic to plants.

pupa — (pupae, plural) the resting, inactive stage between the larva and the adult in all insects that undergo a complete metamorphosis.

pupate — the process of changing from a larva to a pupa.

raster — in scarab larvae, a complex of definitely arrranged bare places, hairs and spines on the ventral surface of the last abdominal segment, in front of the anus.

rhizome — creeping underground stem.

sign — the pathogen or its parts or products seen on a host plant.

spore — the reproductive unit of fungi consisting of one or more cells.

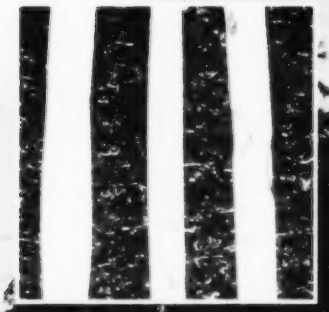
stolon — creeping, above-ground stem.

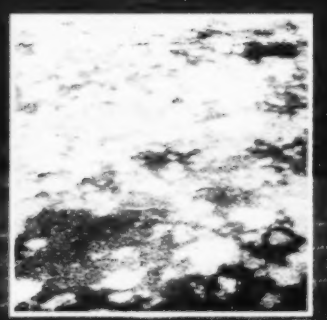
symptom — the external and internal reactions or alterations of a plant as a result of a disease.

topdressing — a prepared rootzone mix added to a turfgrass surface and worked in by brushing, matting, raking or irrigating. Used to smooth the putting surface and control thatch.

thatch — the layer of living and dead tissue between the soil surface and green vegetation in turf.

vericutting — the use of a mechanical device that has vertically rotating blades that cut into the surface of a turf for the purpose of removing excess thatch or controlling turf grain.





www.omaf.gov.on.ca

Ontario